



US007802631B2

(12) **United States Patent**  
**McKinley et al.**

(10) **Patent No.:** **US 7,802,631 B2**  
(45) **Date of Patent:** **\*Sep. 28, 2010**

(54) **GROUND ENGAGING AGRICULTURAL TINE AND ASSOCIATED MOUNTING AND INDEXING SYSTEM**

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 315 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/611,999**

(22) Filed: **Dec. 18, 2006**

(65) **Prior Publication Data**

US 2007/0187122 A1 Aug. 16, 2007

**Related U.S. Application Data**

(63) Continuation of application No. 10/943,168, filed on Sep. 16, 2004, now Pat. No. 7,172,032.

(60) Provisional application No. 60/503,372, filed on Sep. 16, 2003.

(51) **Int. Cl.**  
*A01B 45/02* (2006.01)

(52) **U.S. Cl.** ..... 172/21; 172/540; 172/549

(58) **Field of Classification Search** ..... 172/21, 172/22, 55, 56, 57, 58, 121, 122, 123, 540, 172/554, 548, 549, 550

See application file for complete search history.

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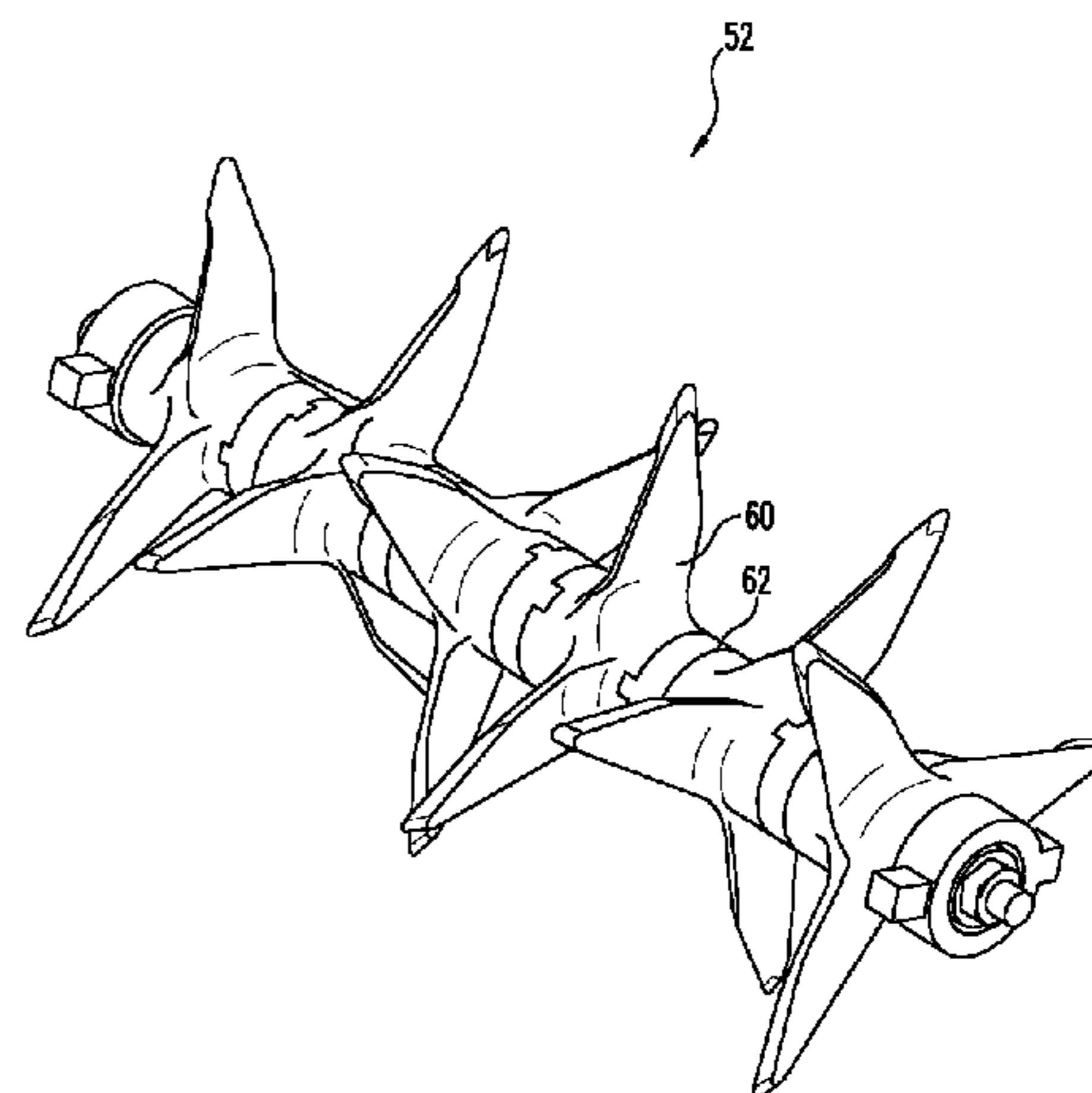
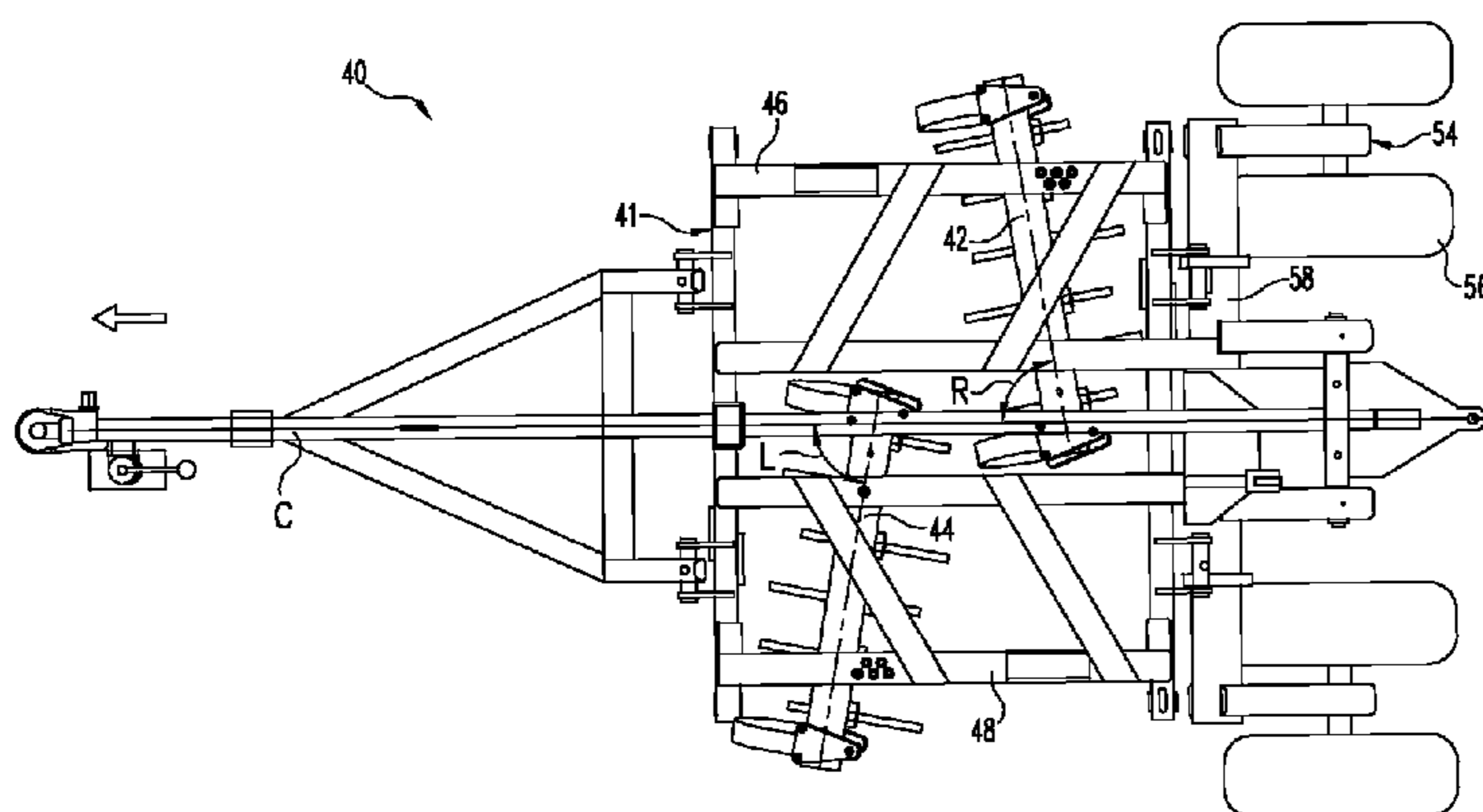
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(57) **ABSTRACT**

An agricultural implement has gangs of soil aerator tools. Each gang includes a set of integral multi-tine units mounted on a frame for rotation in unison. Each tine unit has a hub with tines. The hub has a first surface defining a first set of indexing receivers and a second surface defining a second set of indexing receivers. At least one indexing spacer separates each tine unit from the next tine unit. Keys of the indexing spacers assemble with selected ones of the first set of indexing receivers or the second set of indexing receivers to establish and maintain a predetermined pattern of rotational index positions among tine units in a group and groups in a gang.

A method of rotationally indexing agricultural tools in an assembly. One method includes providing a shaft, tine units, and indexing spacers. Assembly involves sliding a tine unit and an indexing spacer onto the shaft, and assembling in series the tine unit and the indexing spacer on the shaft, such that the indexing spacer orients the tine unit to form an assembly.

**24 Claims, 16 Drawing Sheets**



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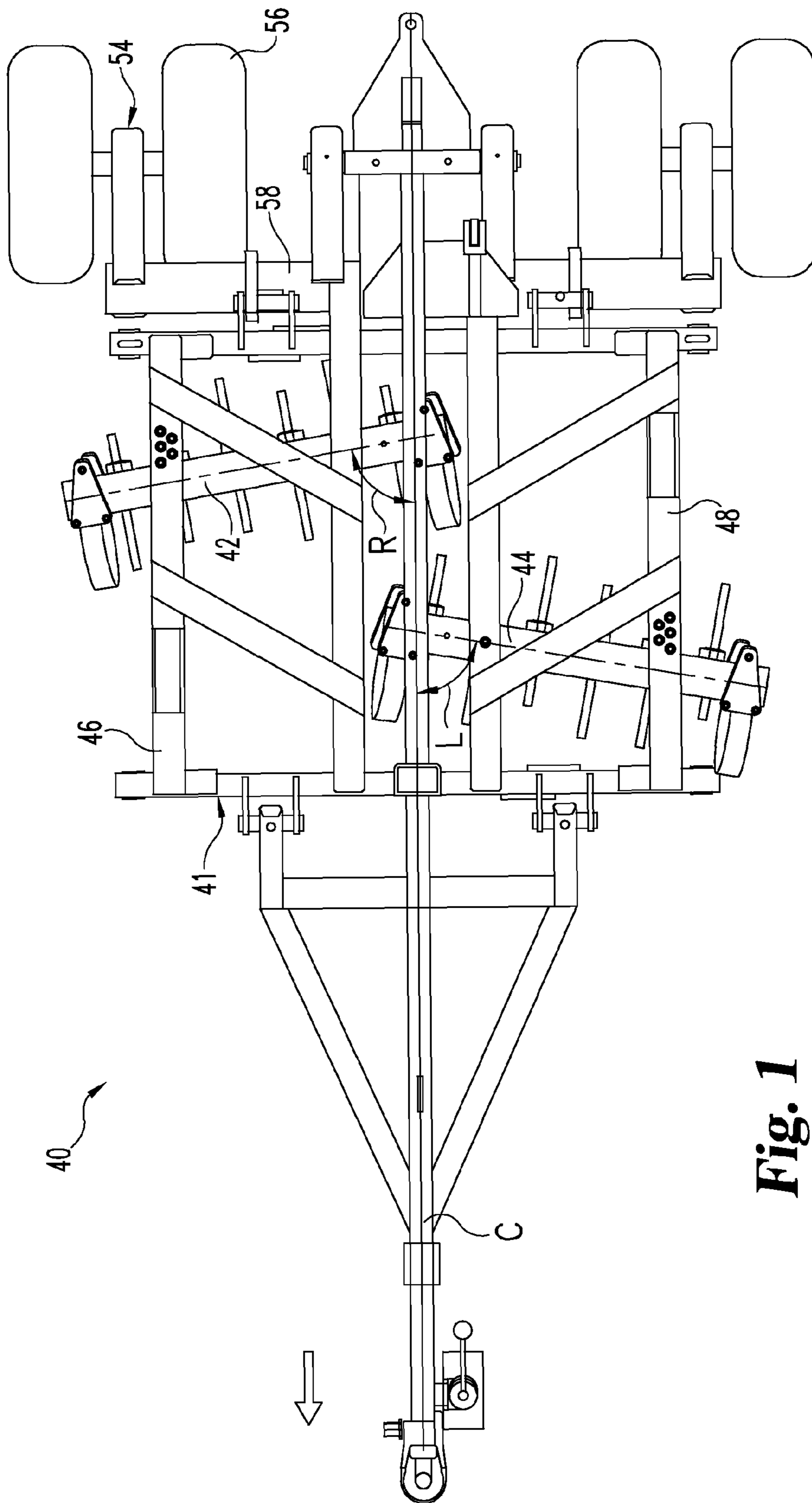
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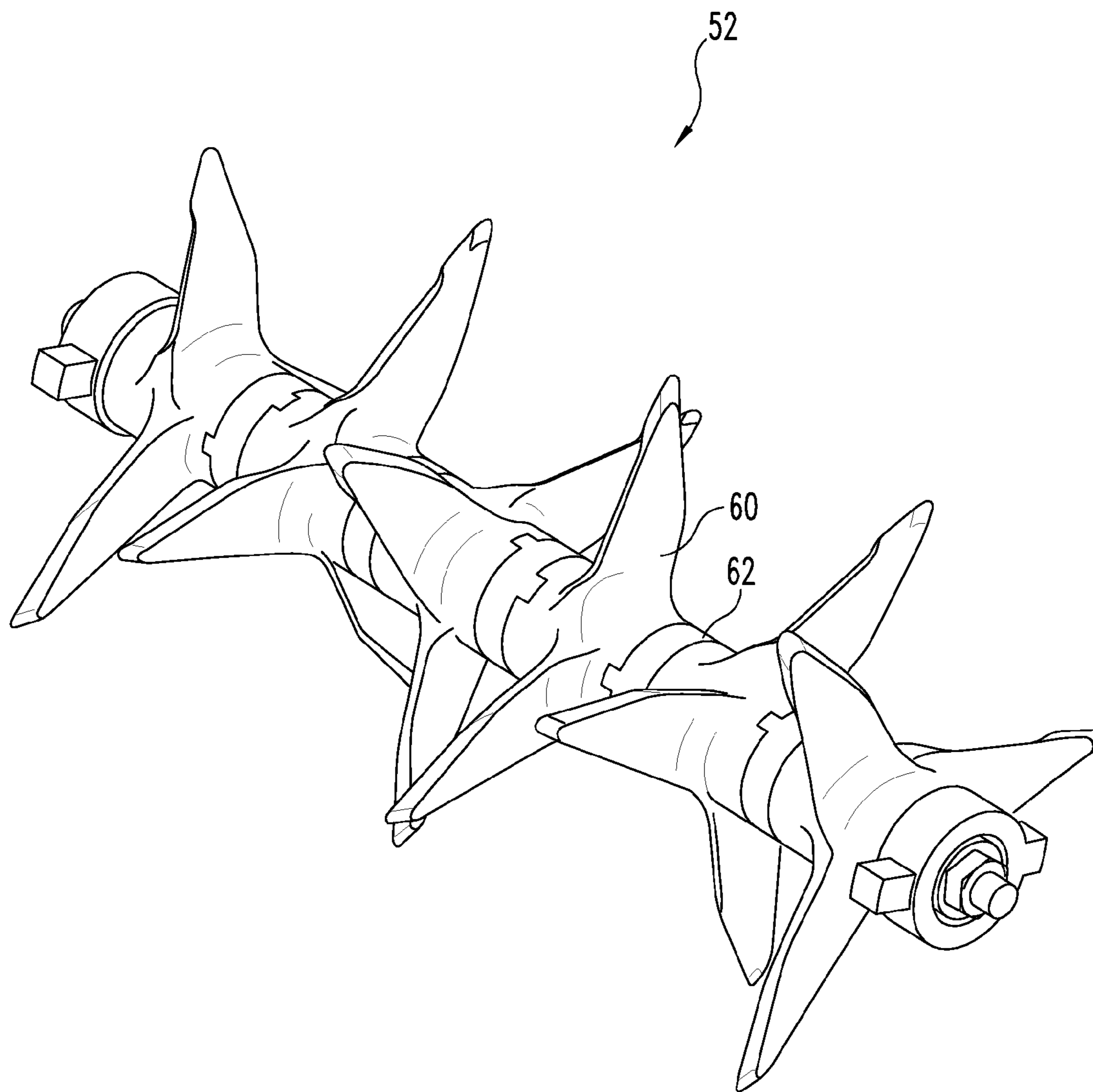
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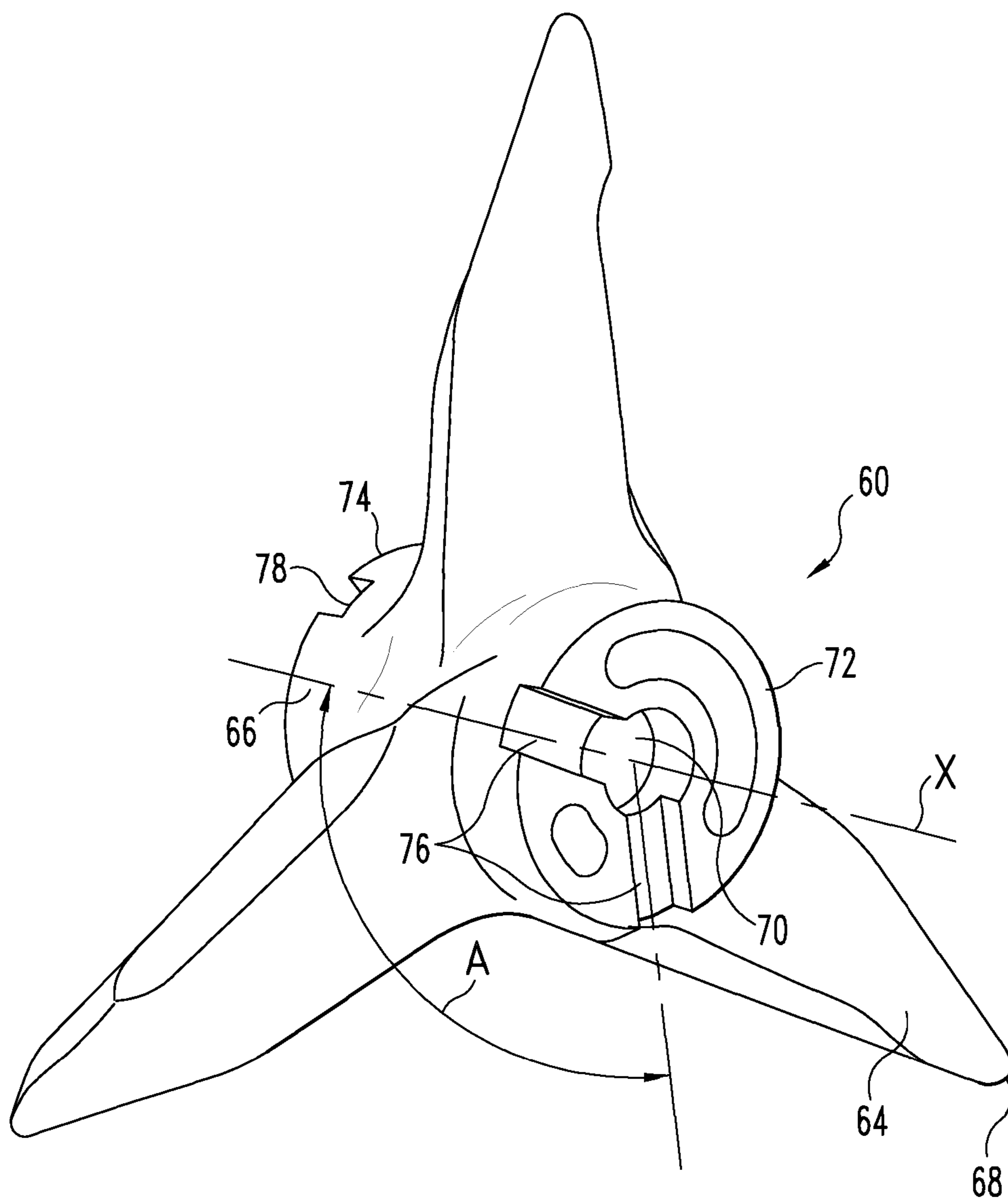
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**Fig. 1**

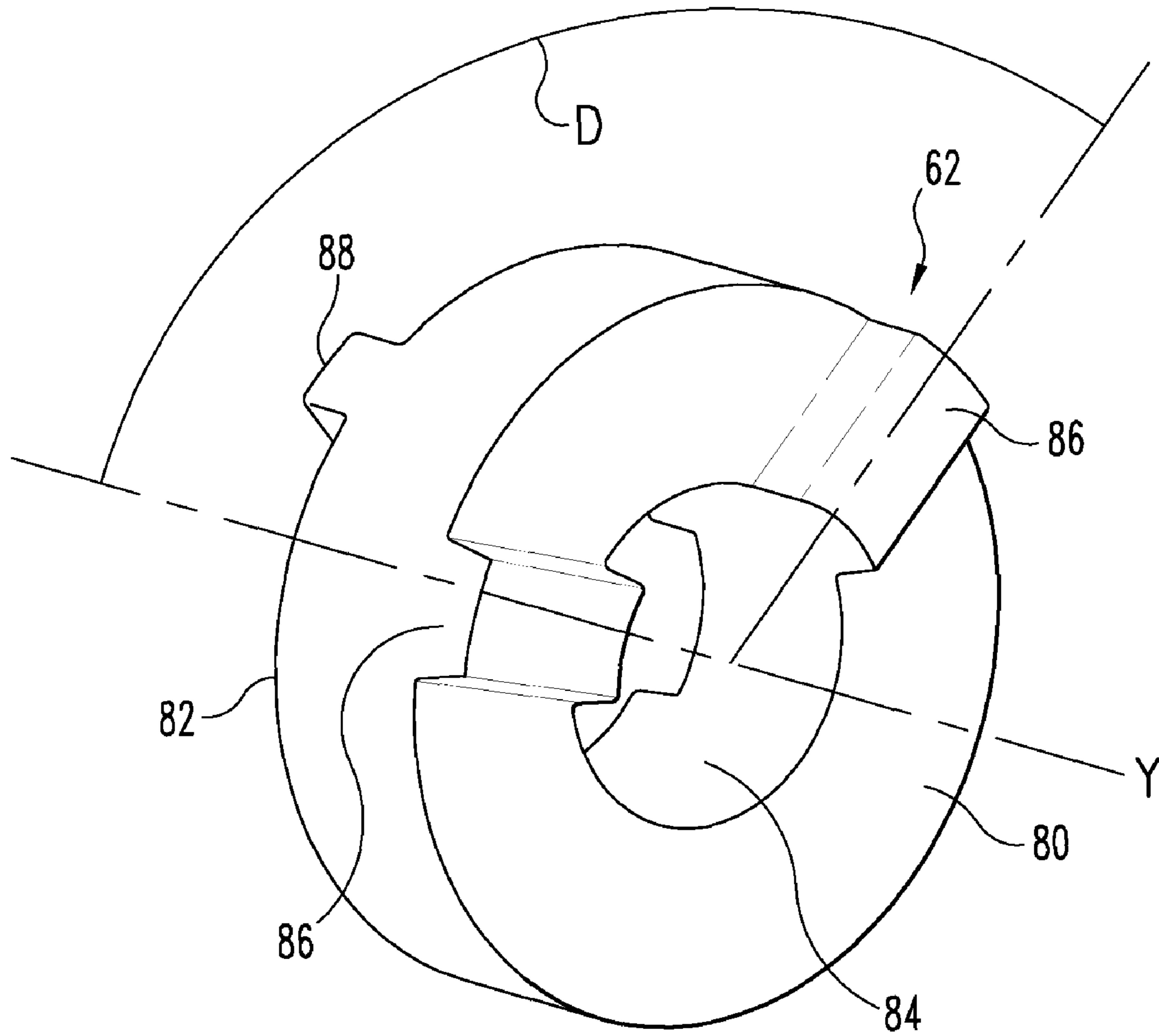


**Fig. 2**

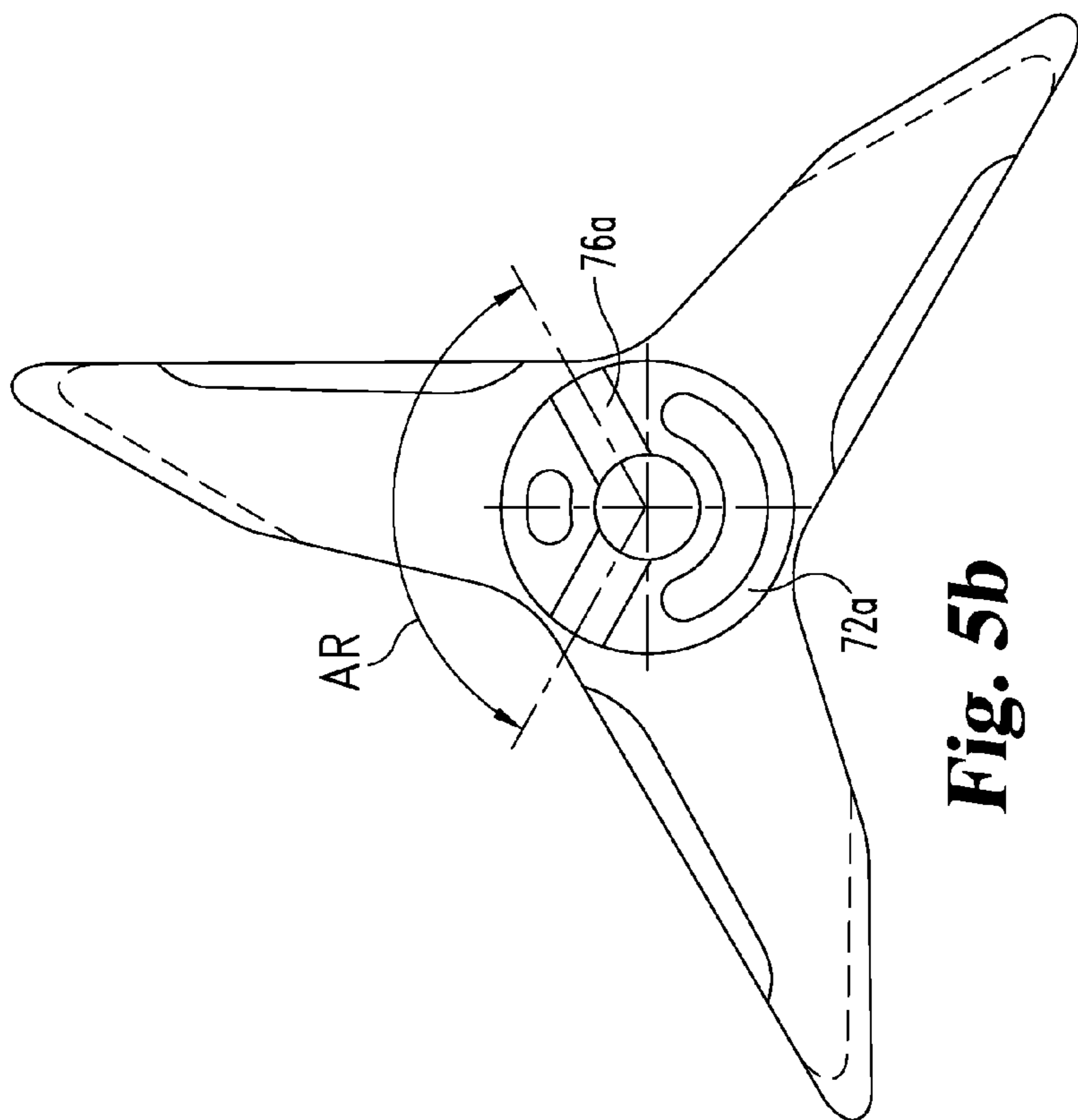


**Fig. 3**

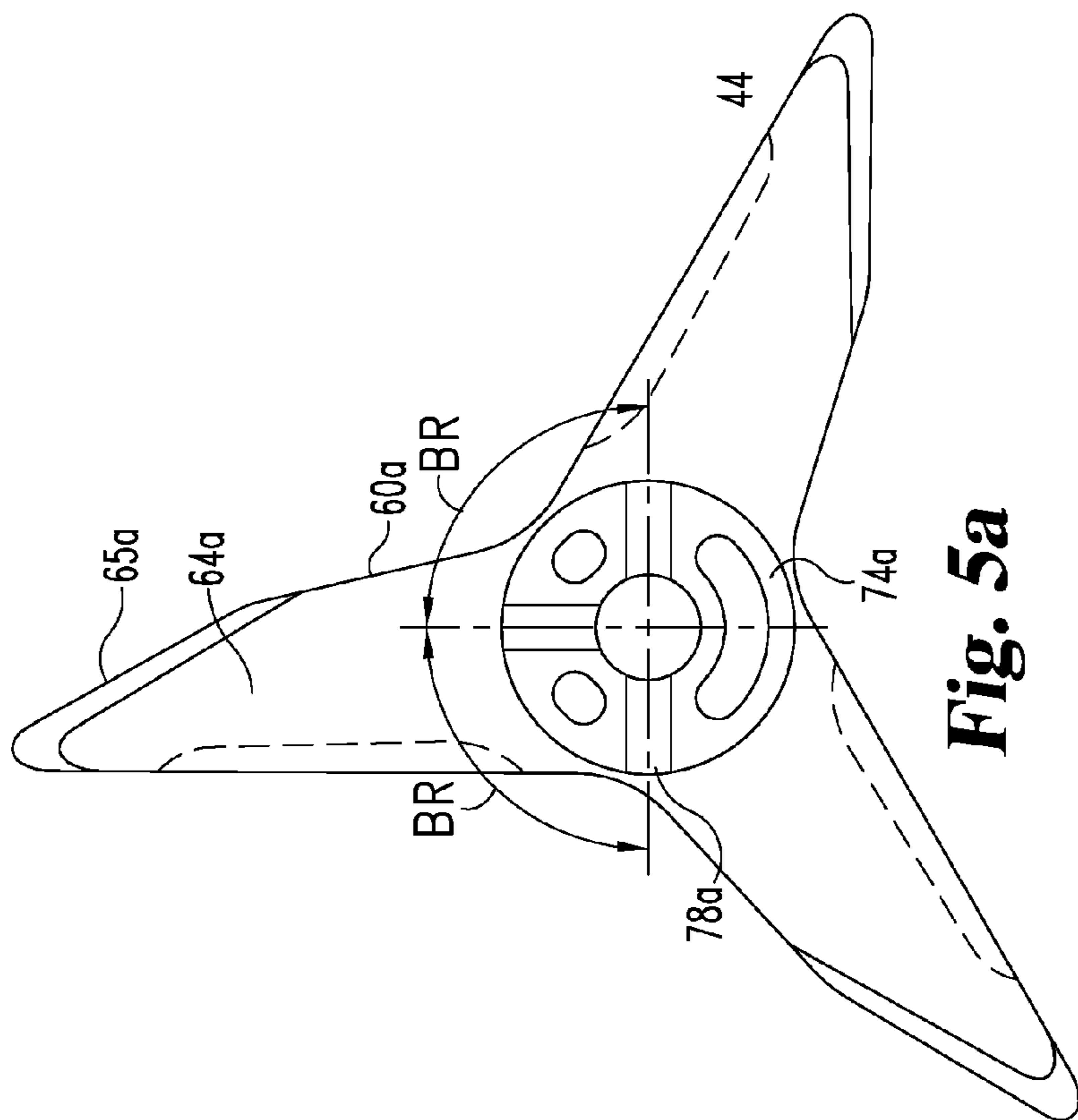




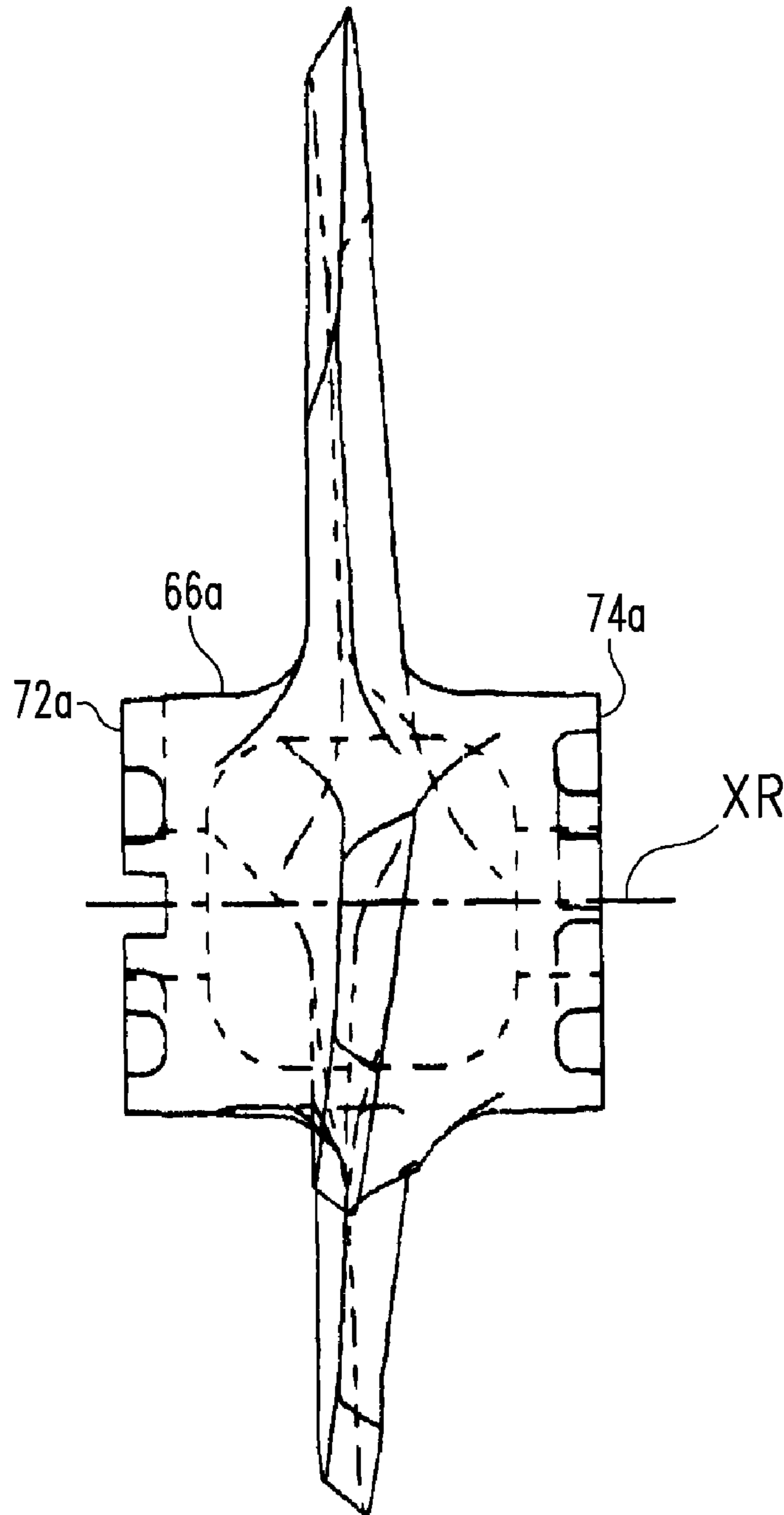
**Fig. 4**



**Fig. 5a**

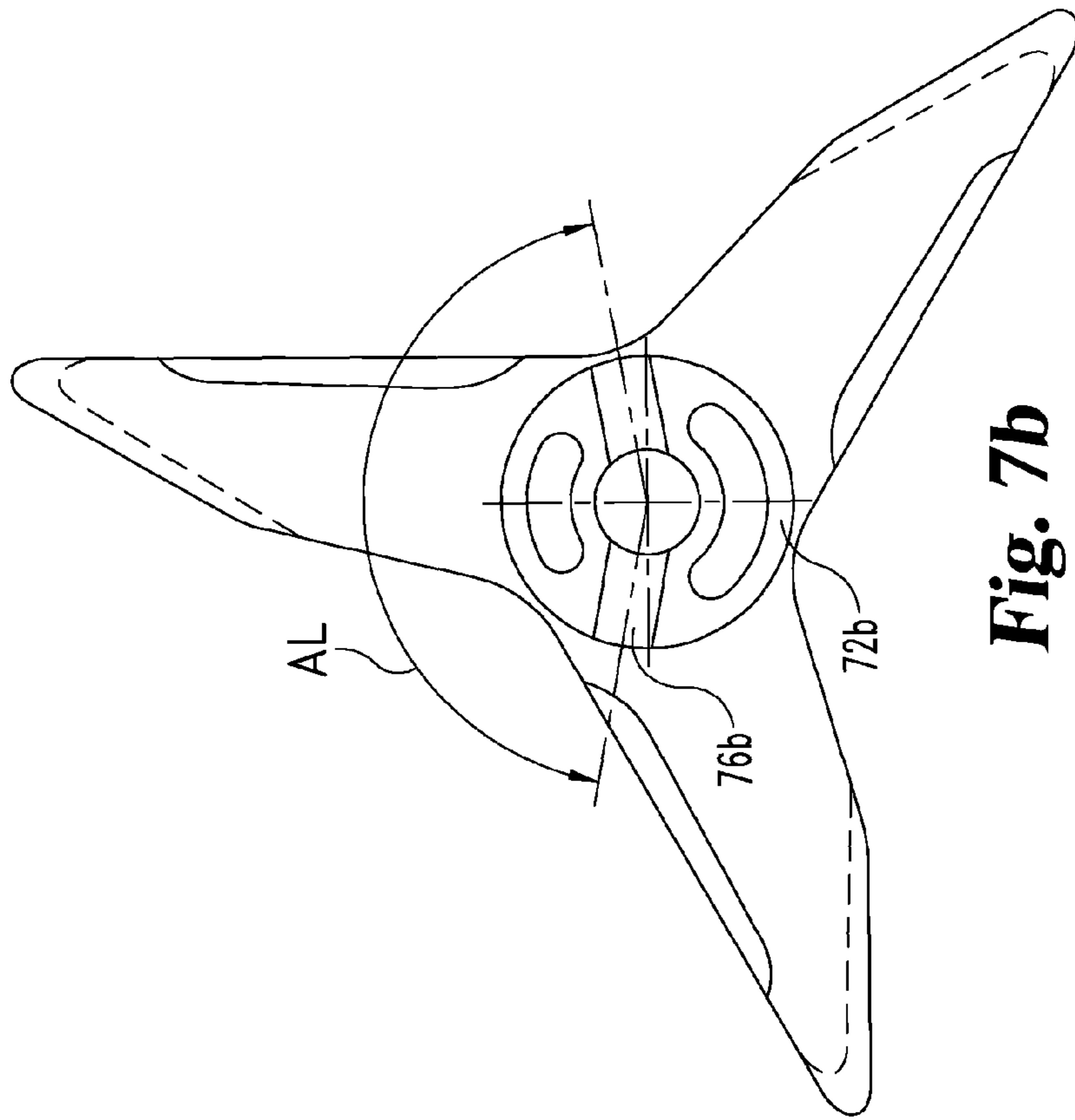


**Fig. 5b**

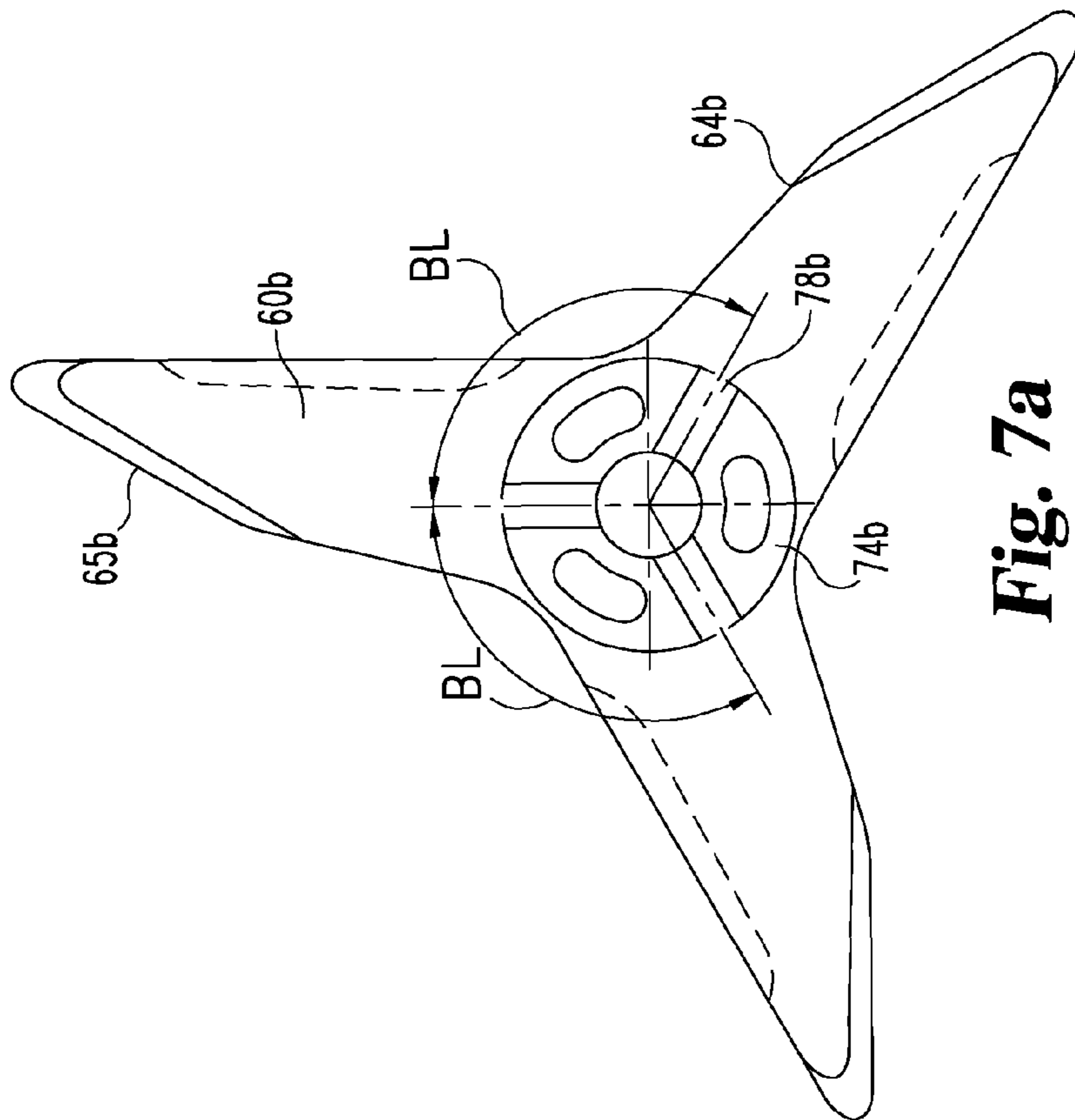


**Fig. 6**

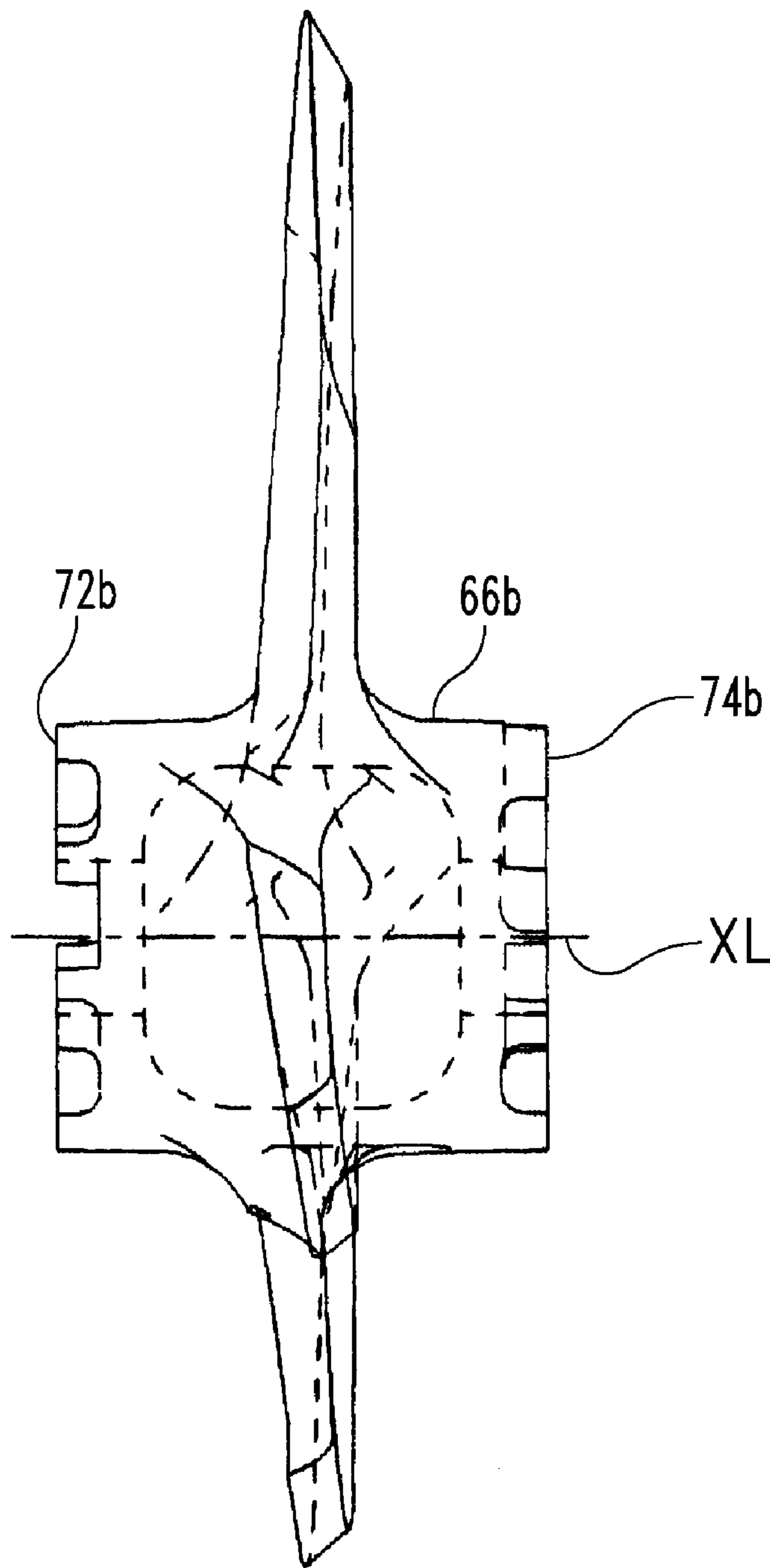




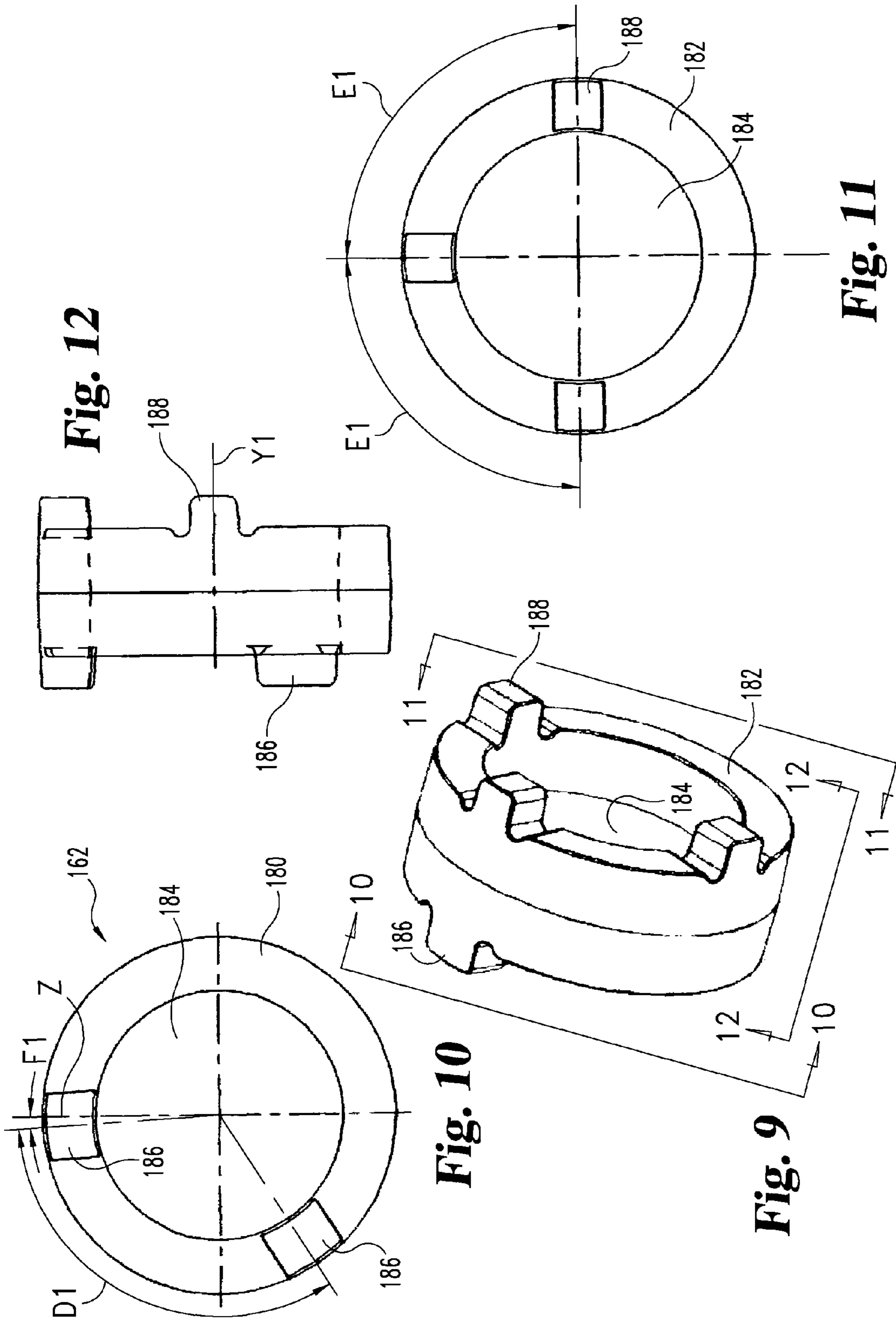
**Fig. 7b**

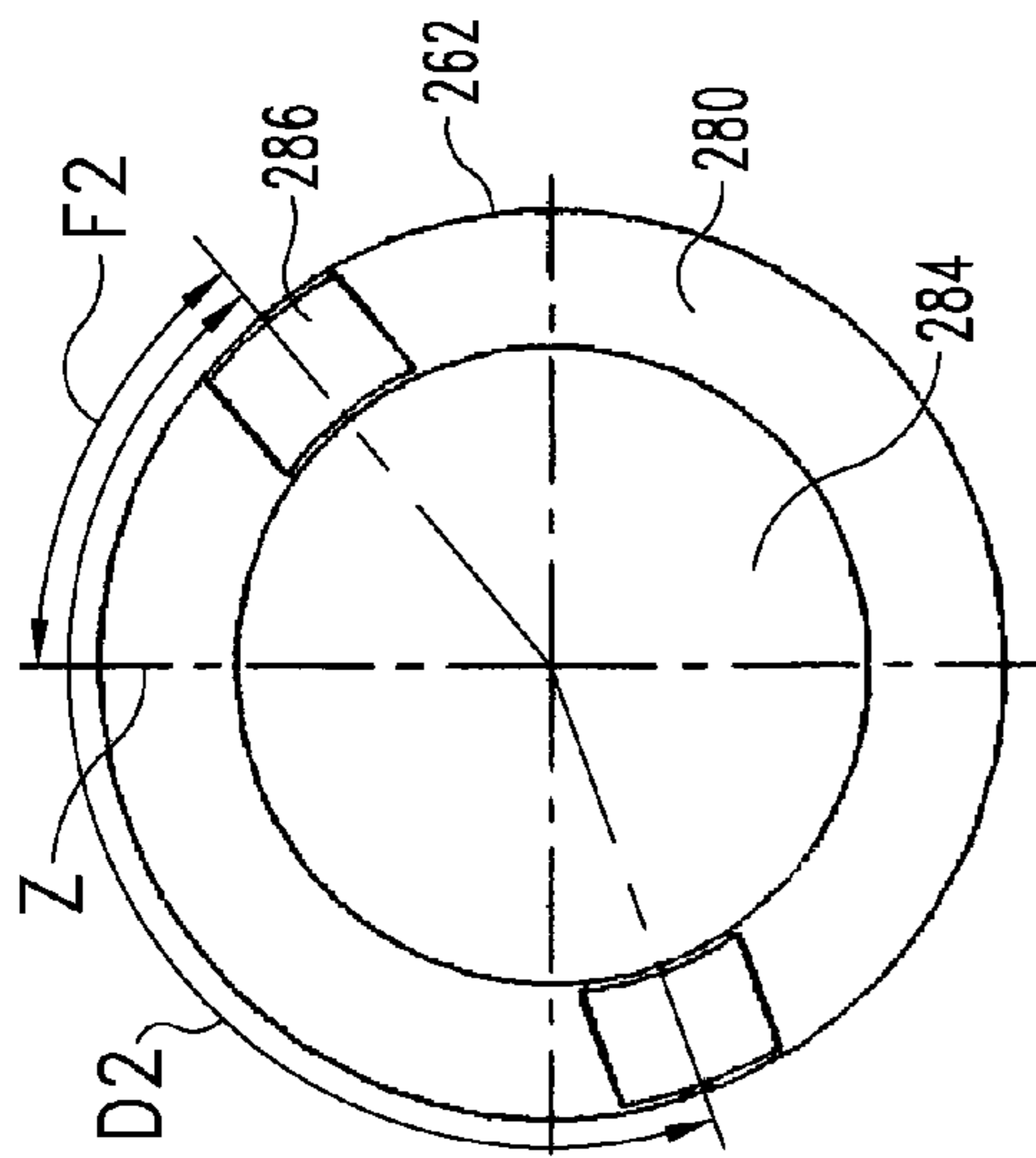


**Fig. 7a**

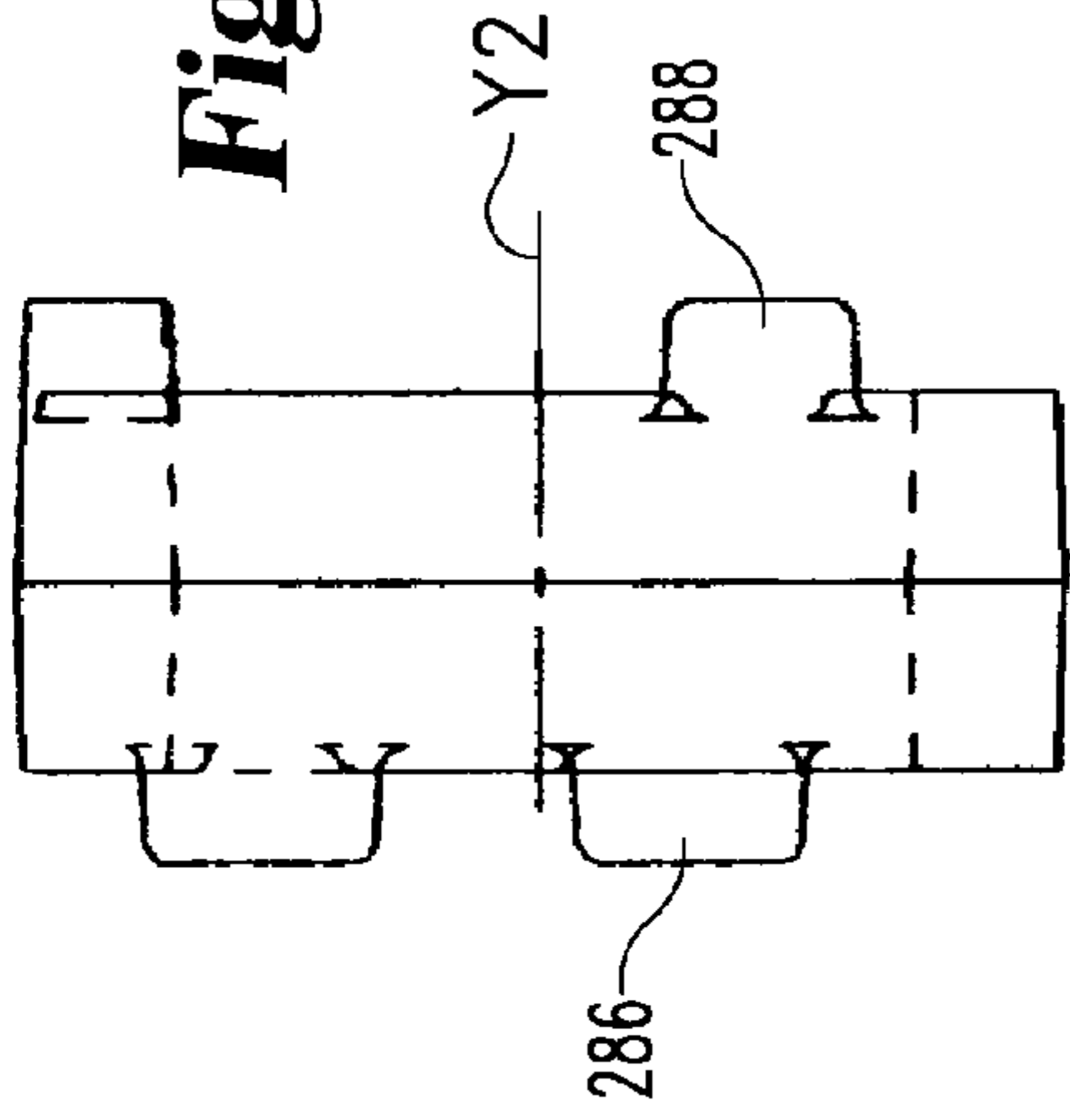


**Fig. 8**

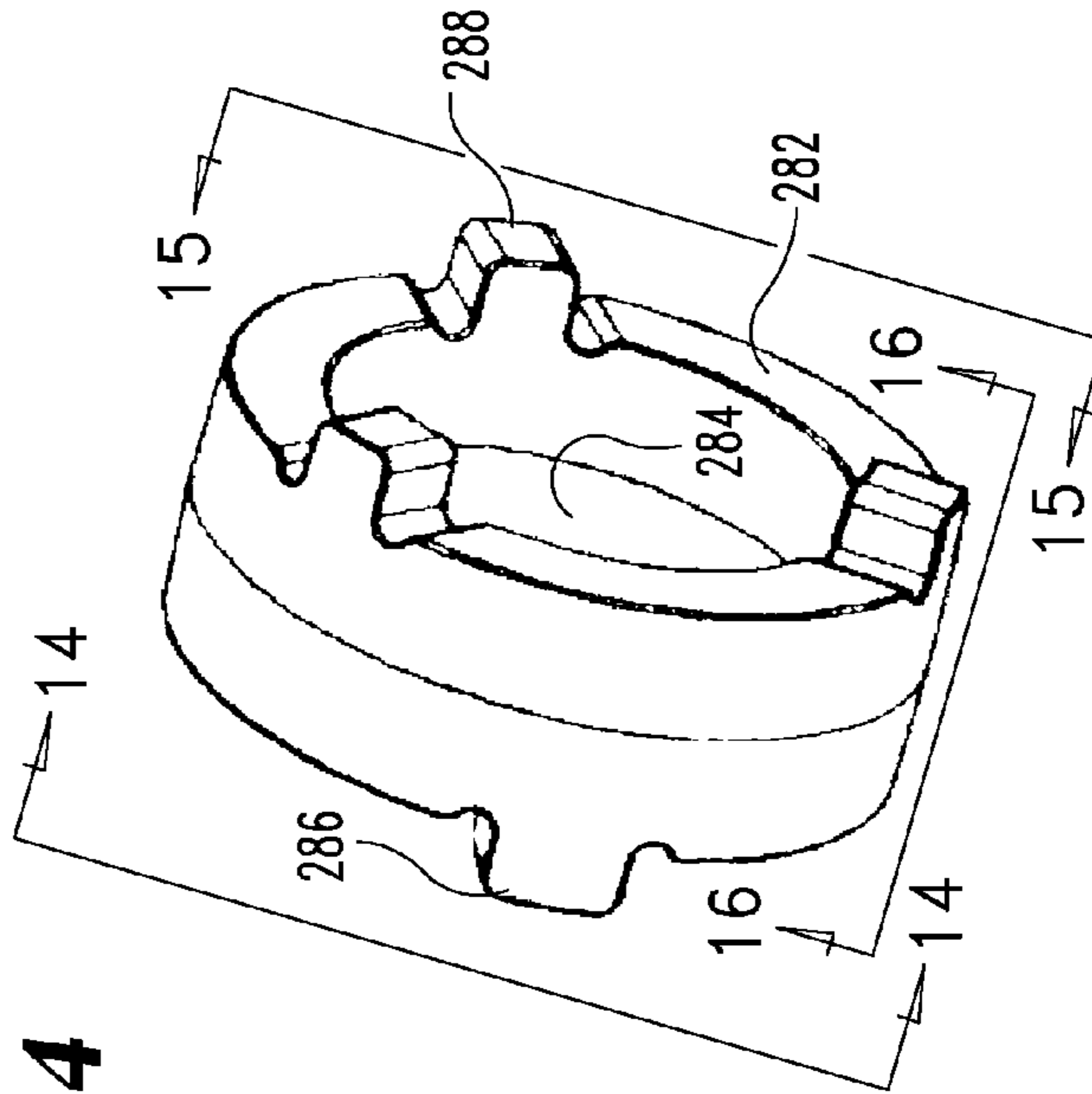




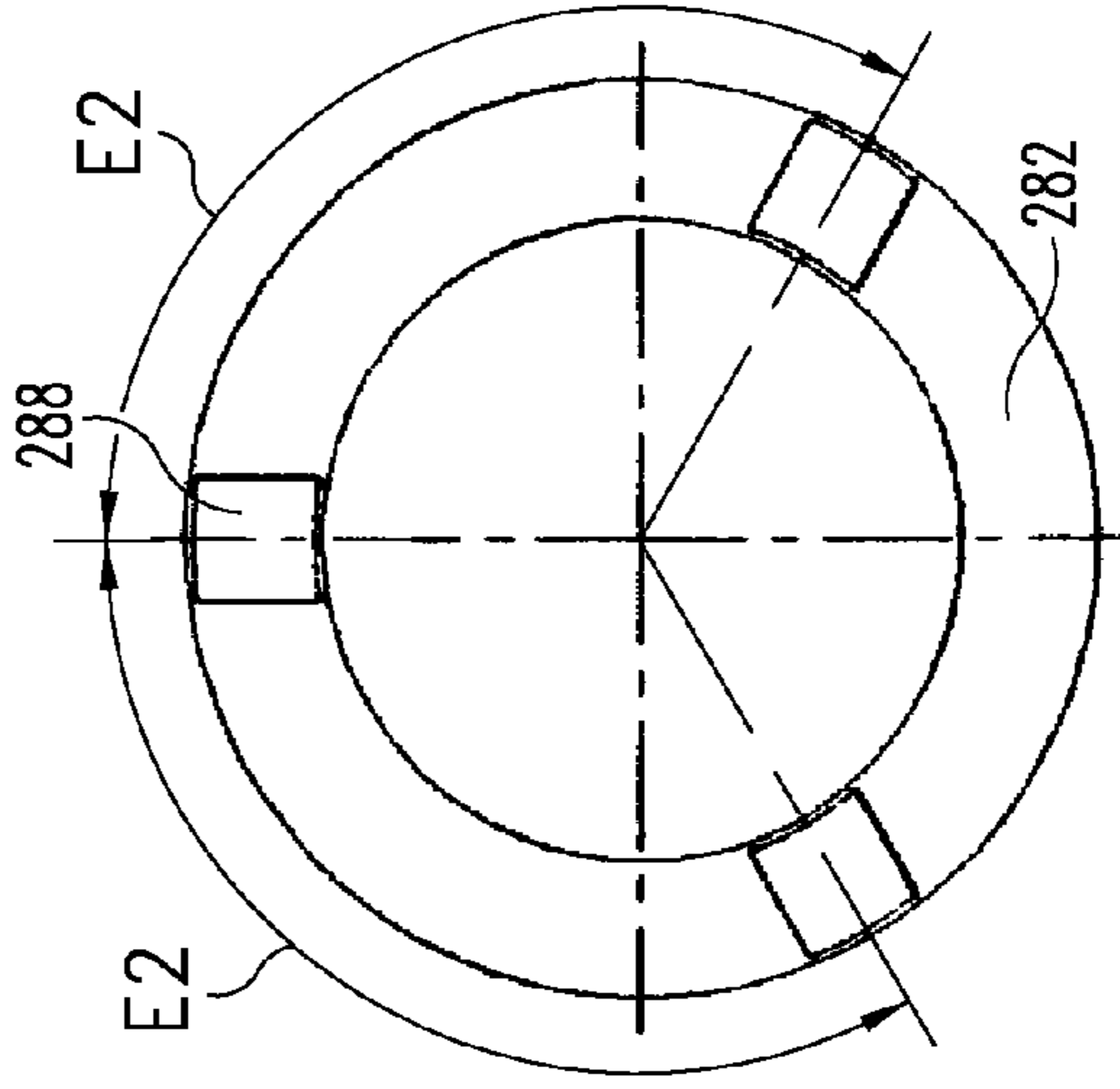
**Fig. 16**



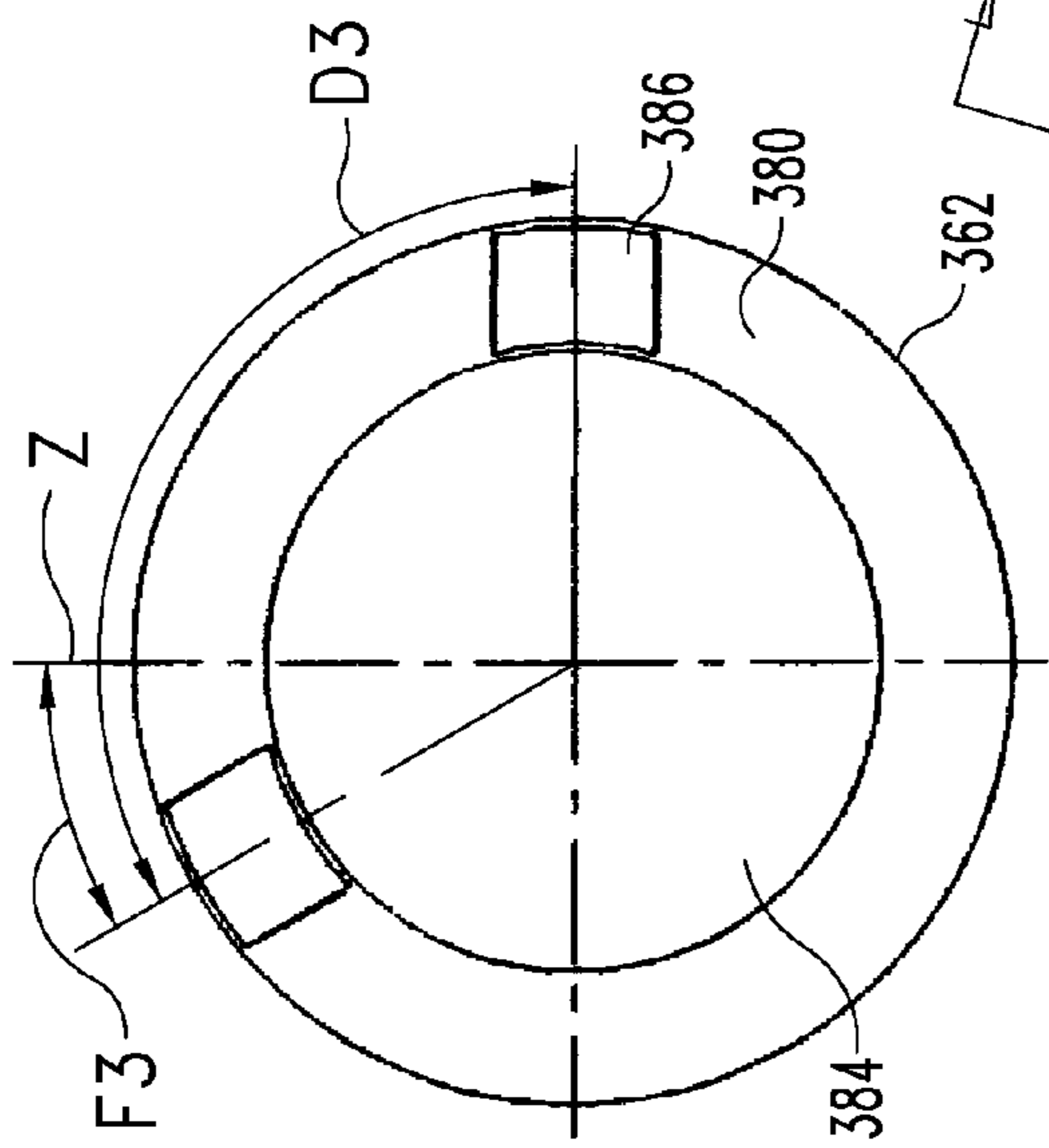
**Fig. 14**



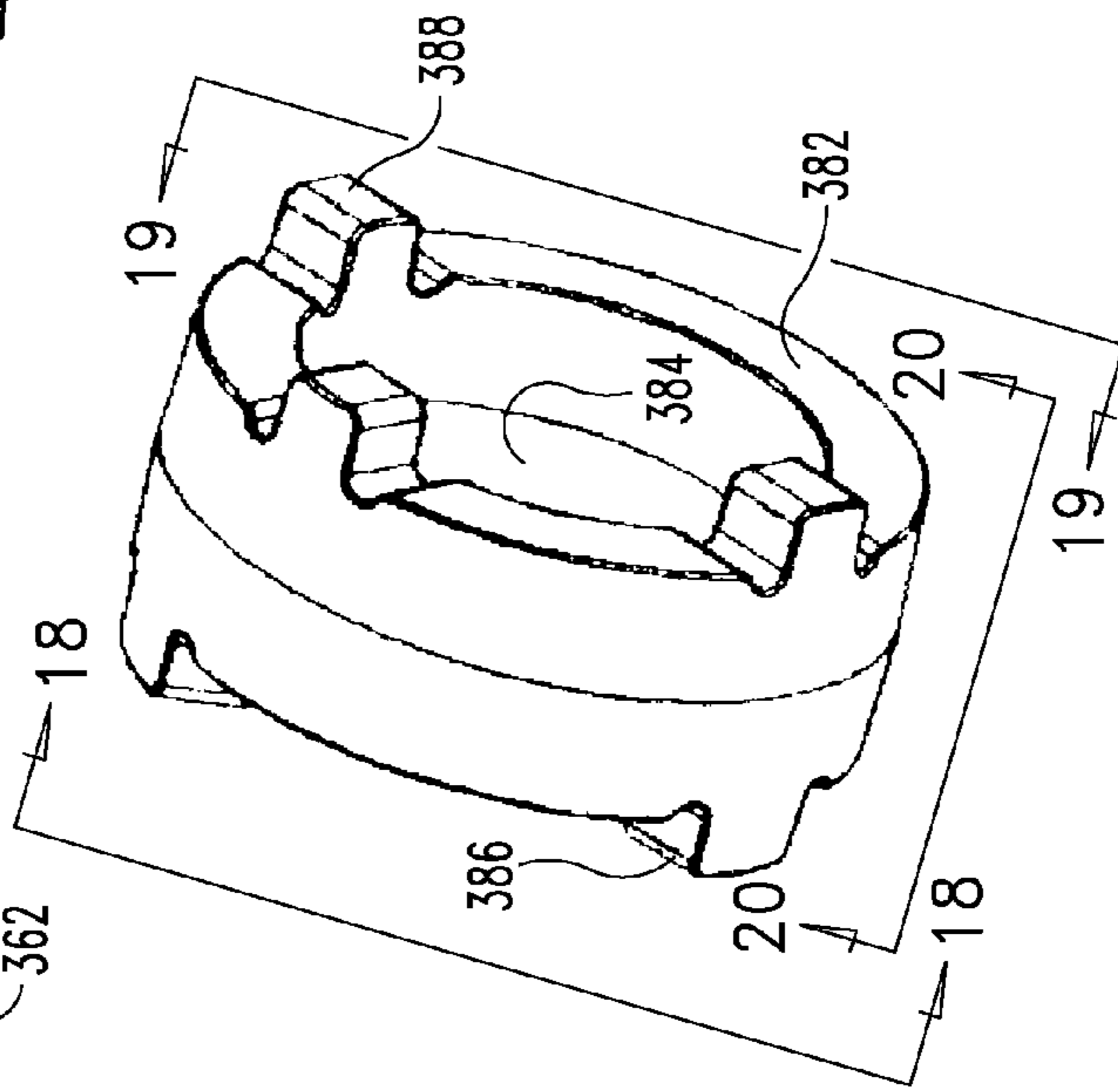
**Fig. 13**



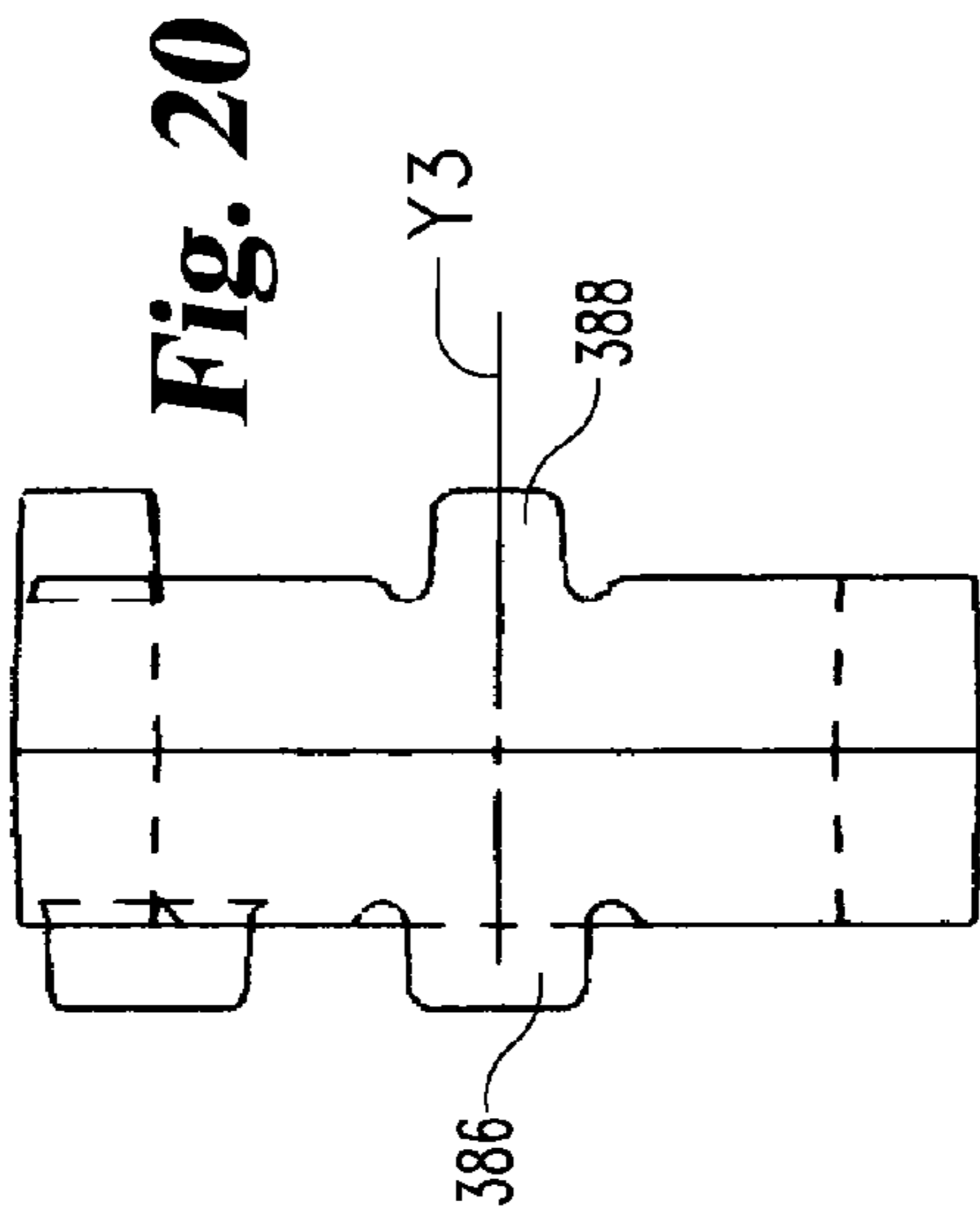
**Fig. 15**



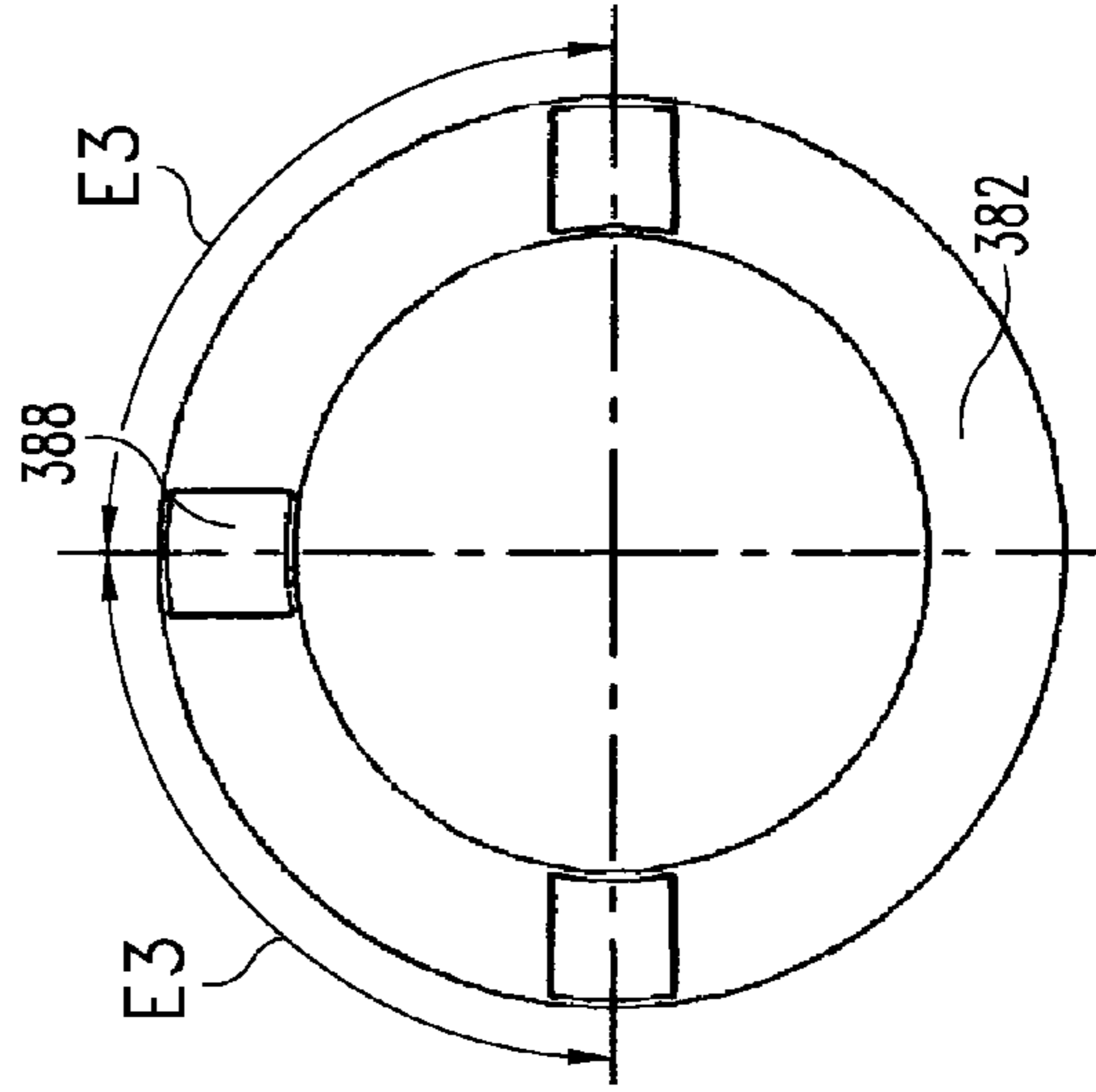
**Fig. 18**



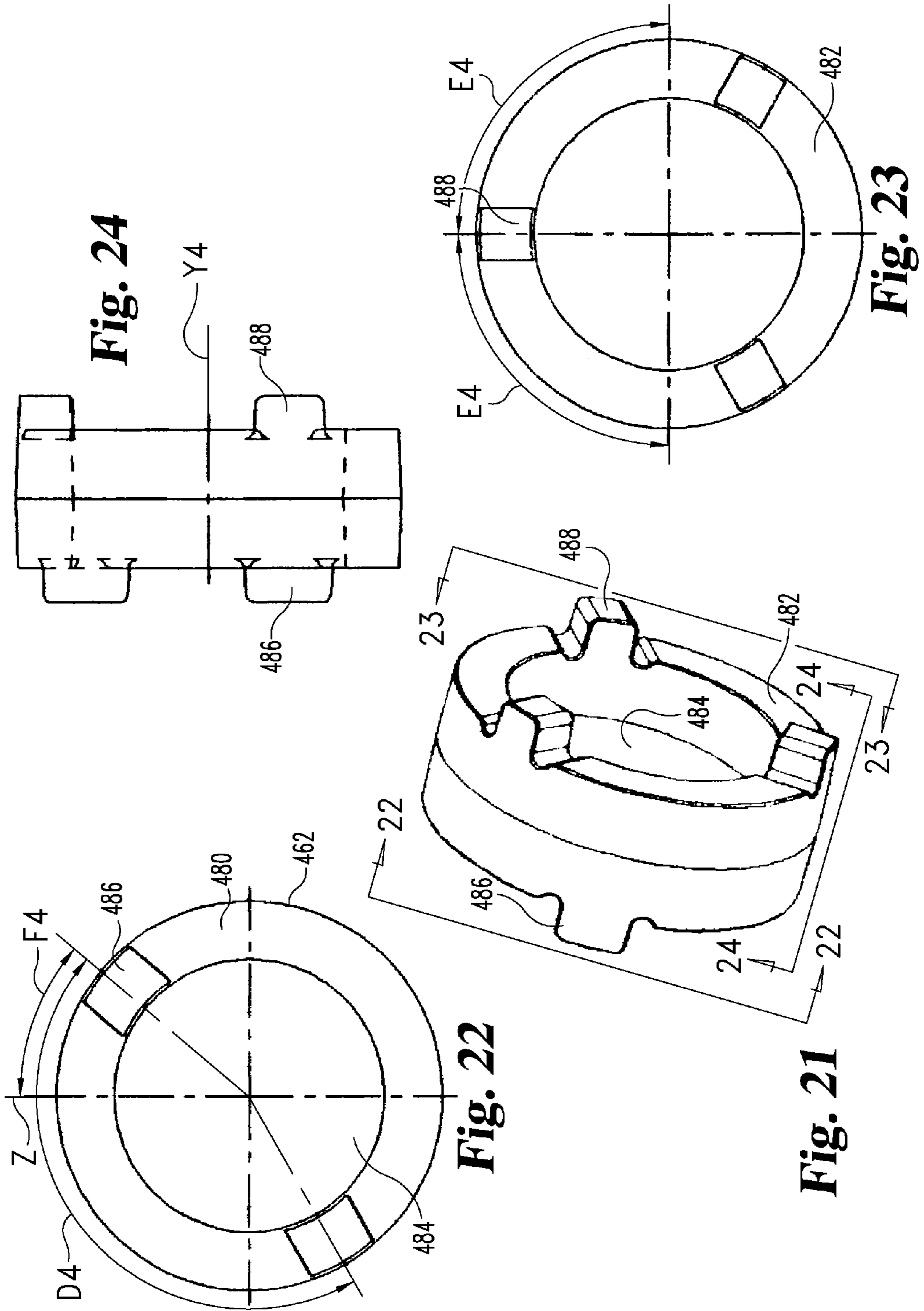
**Fig. 17**



**Fig. 20**



**Fig. 19**





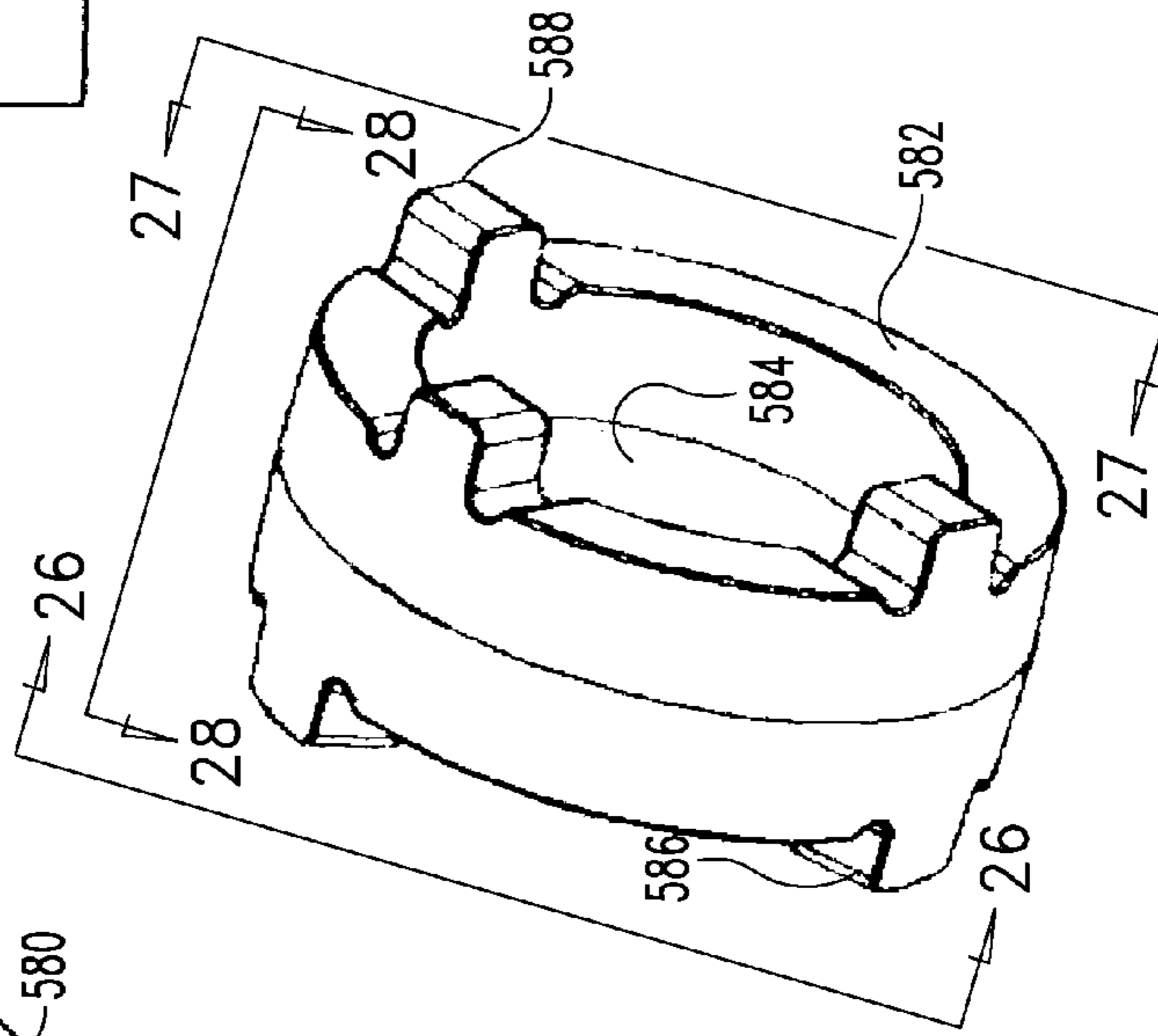
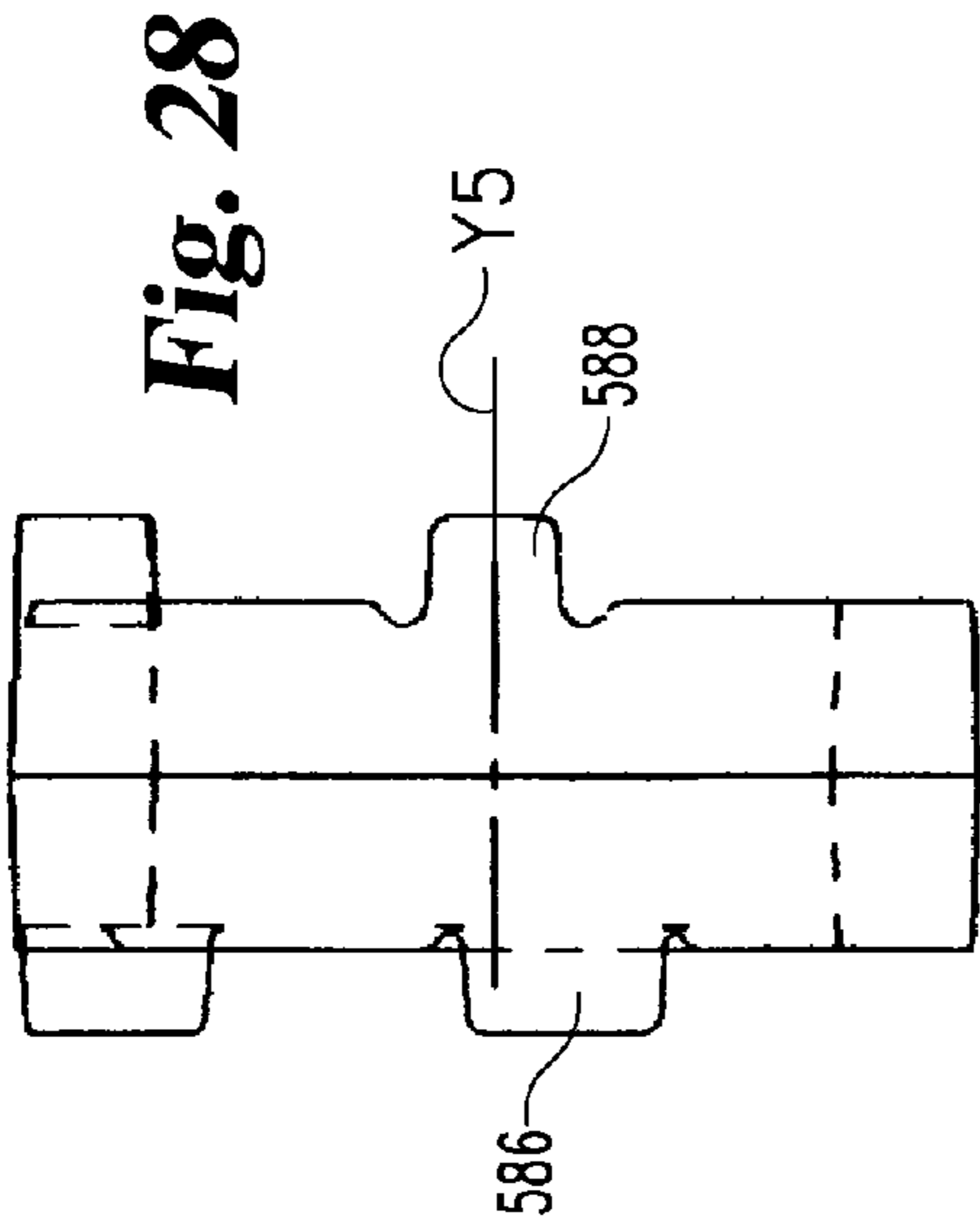
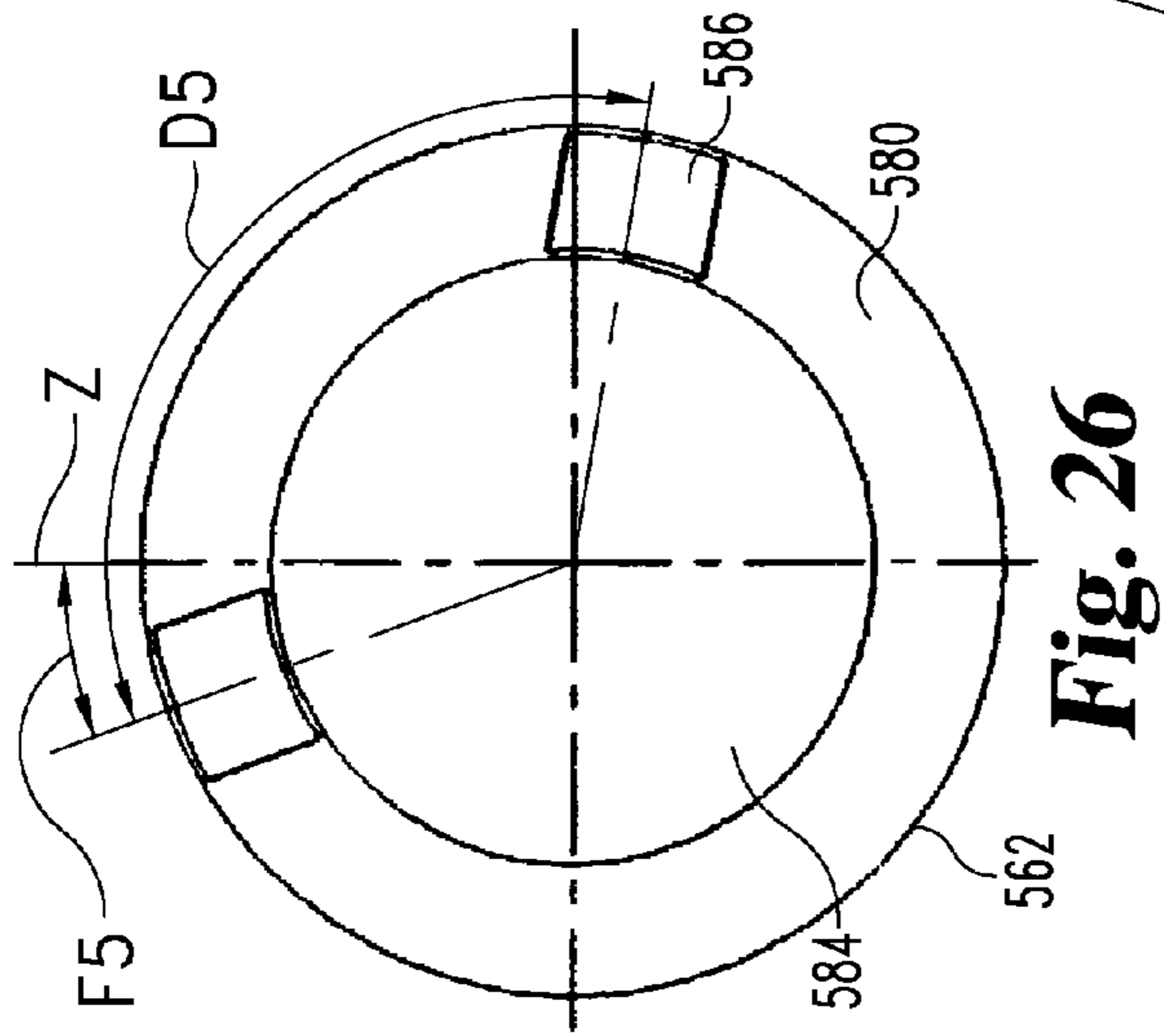


Fig. 26

Fig. 25

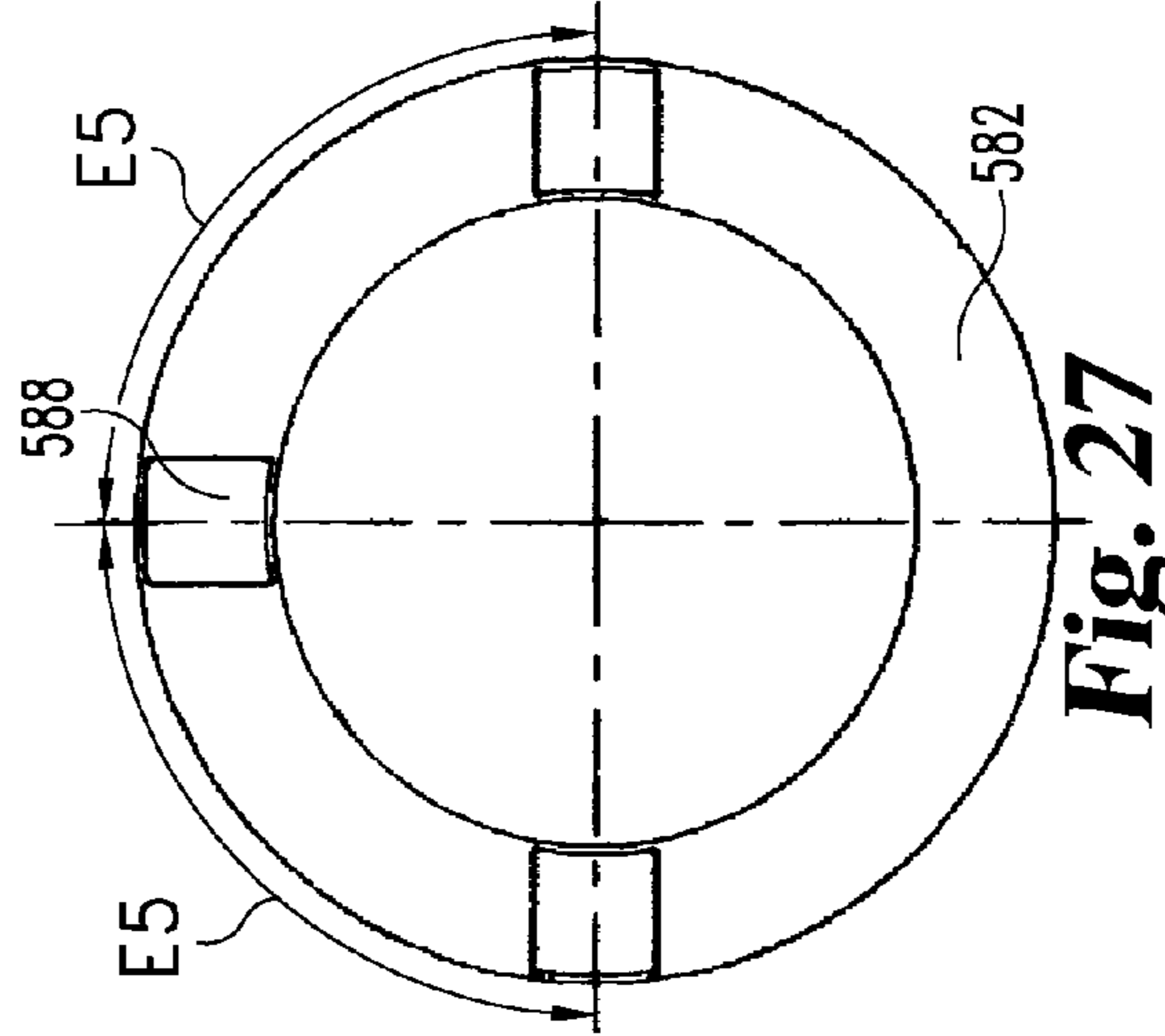
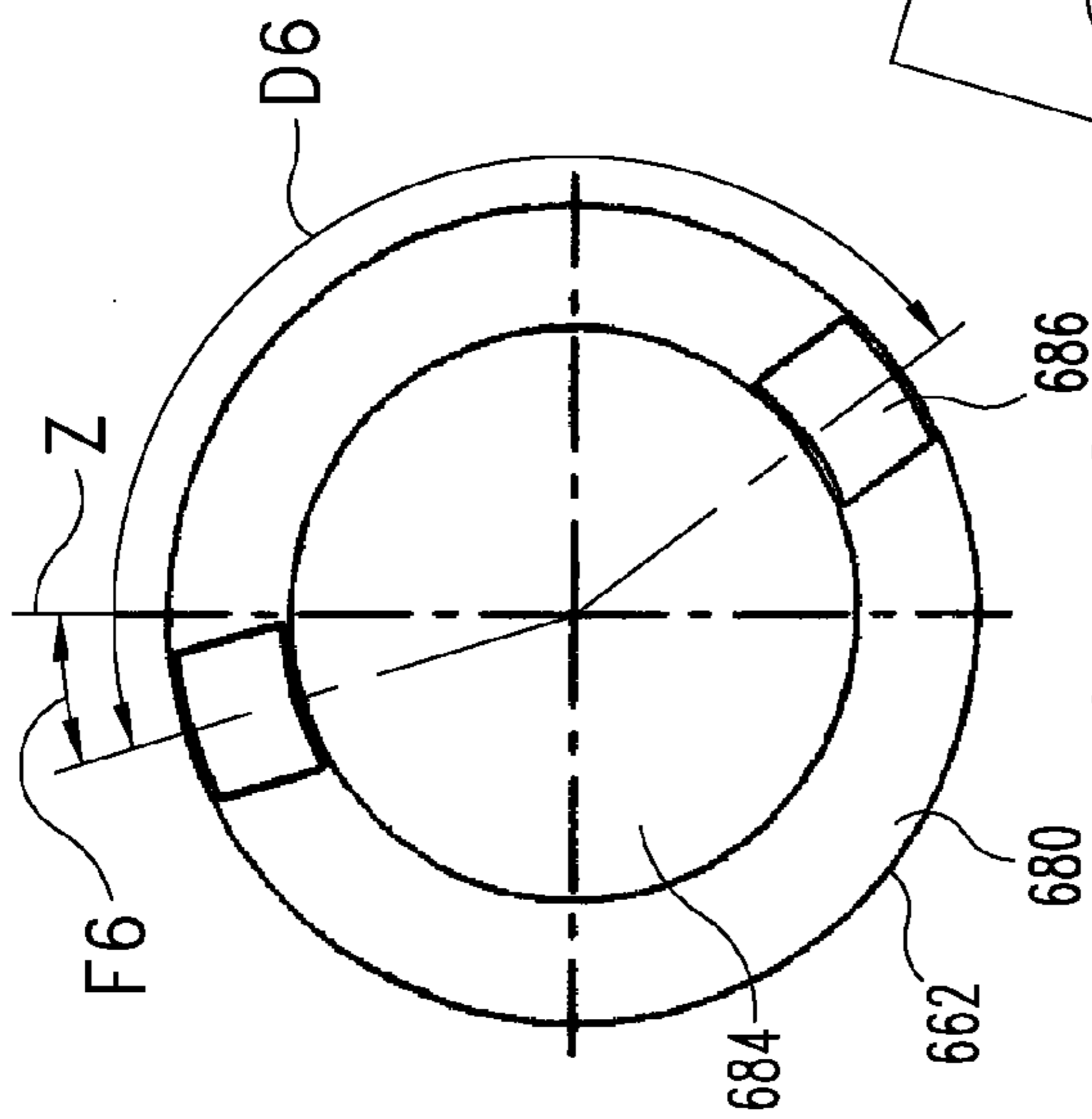
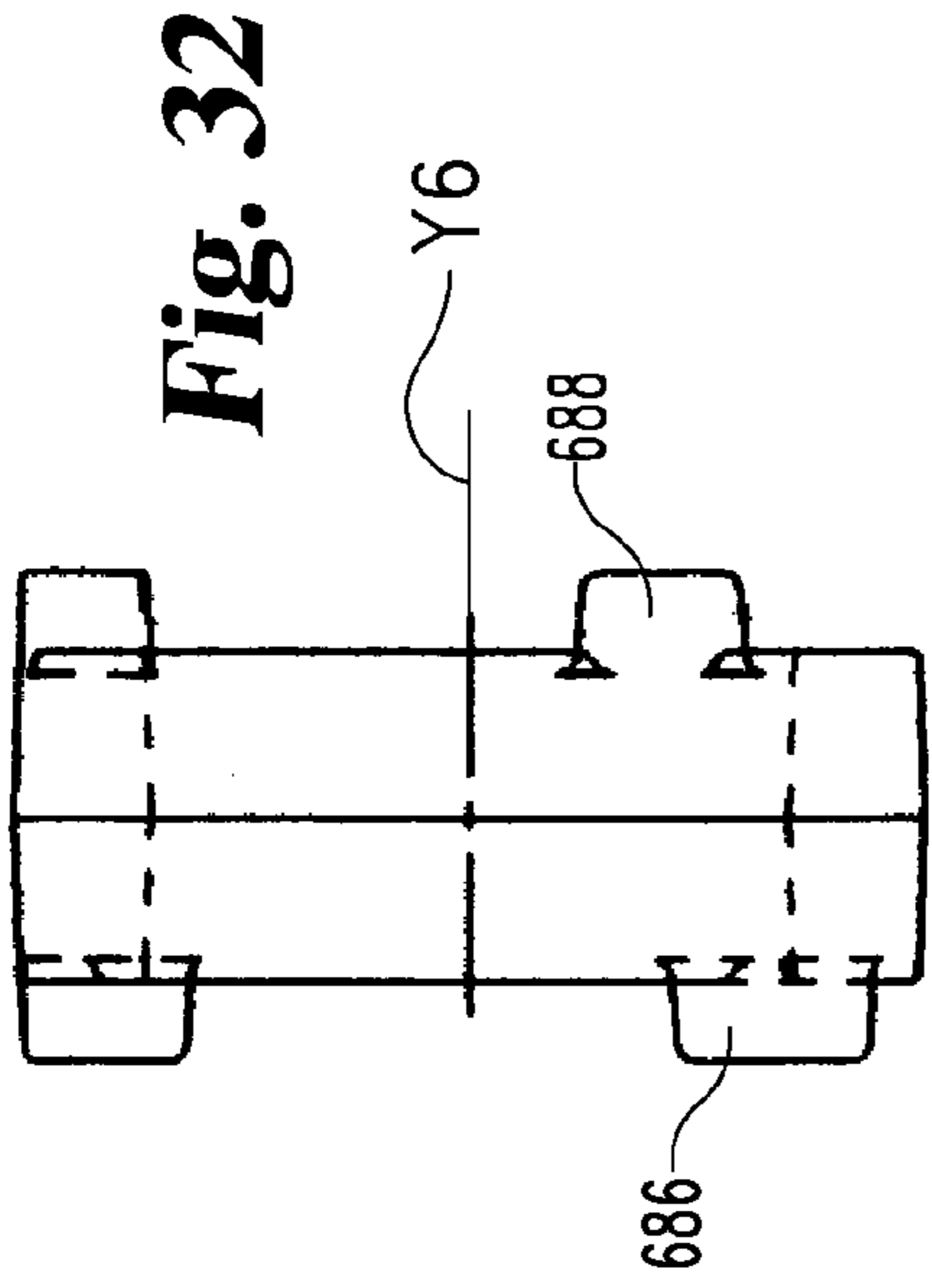


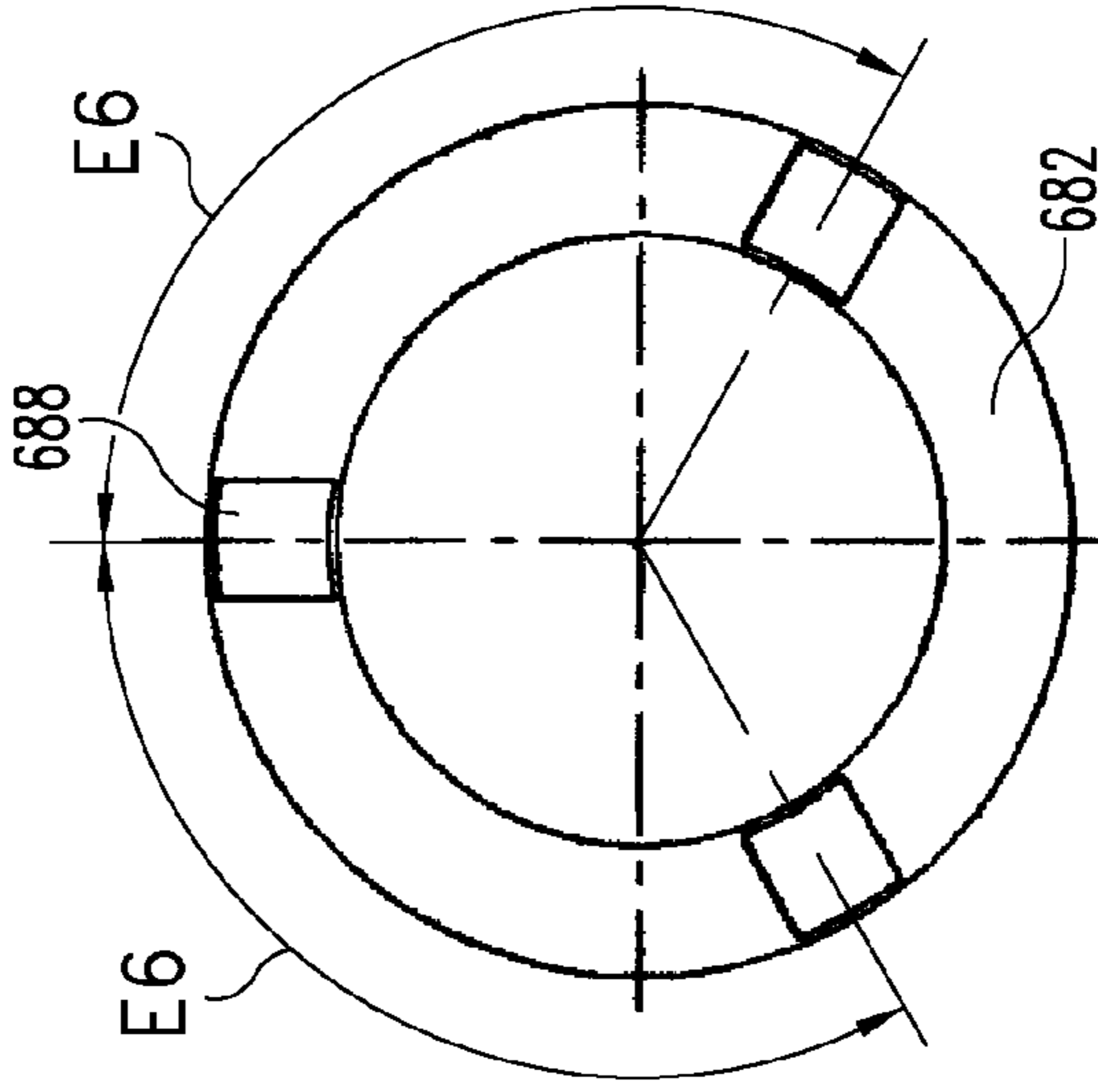
Fig. 27



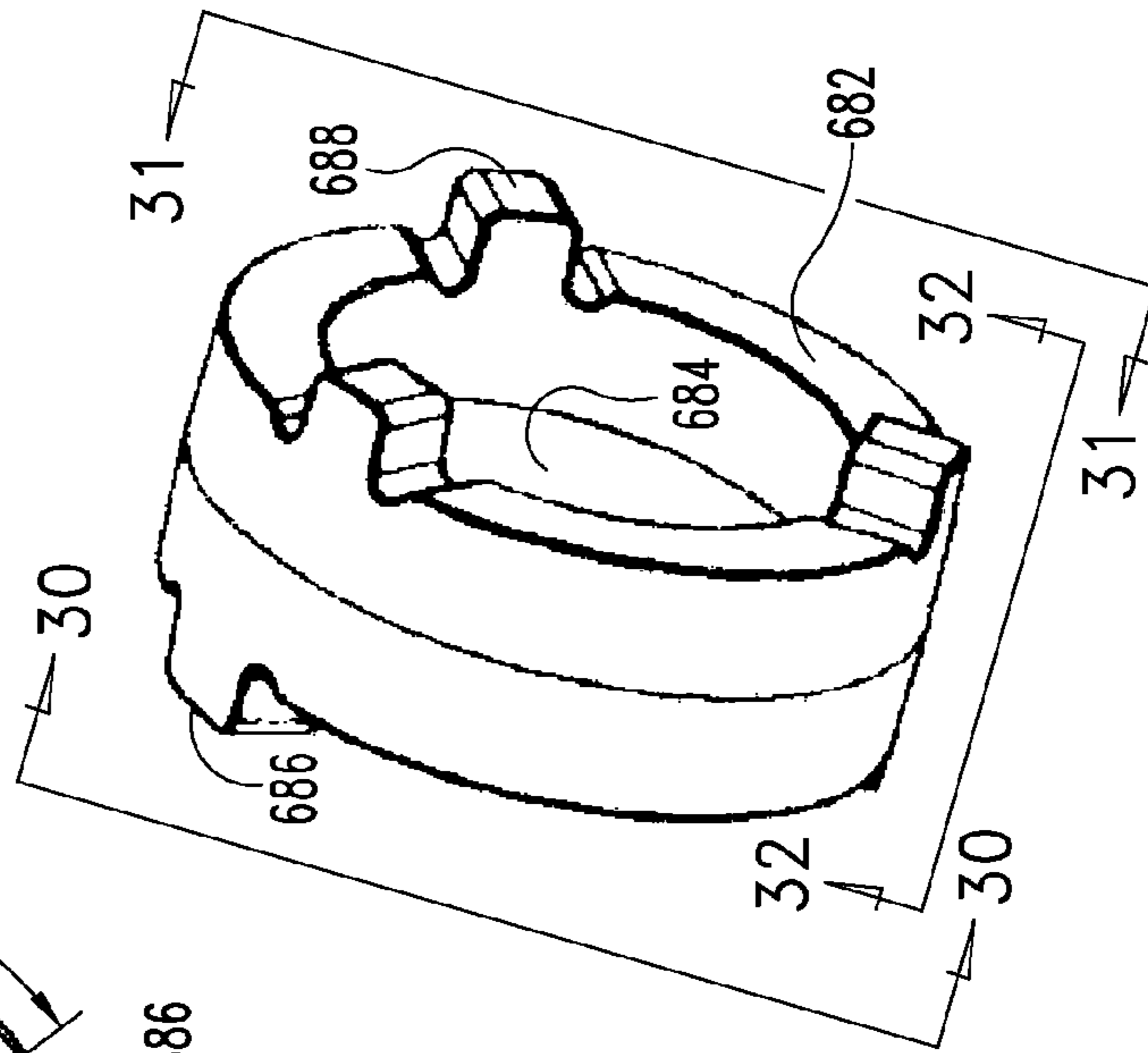
**Fig. 30**



**Fig. 32**

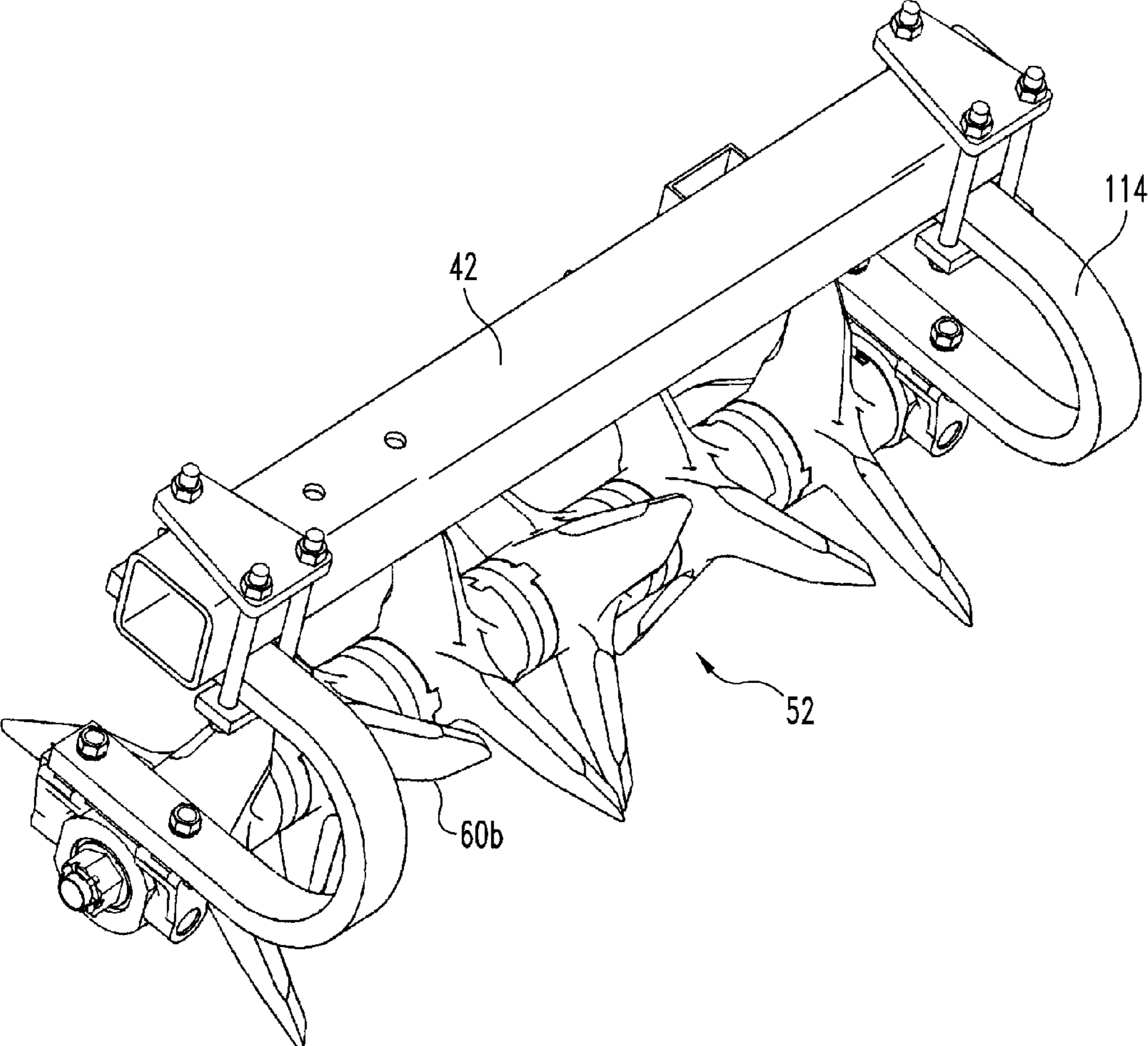


**Fig. 31**



**Fig. 29**





**Fig. 34**



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**GROUND ENGAGING AGRICULTURAL TINE  
AND ASSOCIATED MOUNTING AND  
INDEXING SYSTEM**

CROSS REFERENCE TO RELATED  
APPLICATION

This application is a continuation of U.S. patent application Ser. No. 10/943,168 filed Sep. 16, 2004 now U.S. Pat. No. 7,172,032, which claims the benefit of U.S. Provisional Patent Application Ser. No. 60/503,372, filed Sep. 16, 2003, which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates to methods and apparatus for working soil. More specifically, the present invention relates to the use of ground engaging tine units that are mounted on gang assemblies and rotatably advanced in an order determined by an indexing system.

Typically, a tractor is attached to an aerator to pull the aerator behind it. The agriculture industry recognizes the importance of using an aerator for aerating soil. One form of an aerator includes tine units mounted on a frame such that the tines of the tine units penetrate the soil as the tine units are rotated. The rotation and penetration of tine units into the soil can result in vibration of the aerator, which can be uncomfortable for the operator of the tractor. Often the penetration of the tines into soil is aided by the addition of ballast or weight over the tine units. However, the added ballast can affect the size of tractor required to pull the aerator and ballast. In addition, heavy ballast can be difficult, cumbersome, and/or bulky for an operator to lift and place over the aerator.

During operation of the aerator, tine units can pinch the soil between the face of one tine and the backside of the preceding tine. The pinching of soil aggravates soil lifting and root dislodging which predisposes the soil to erosion.

Another form of an aerator includes a pair of gang assemblies separated by a gap and mounted onto a frame such that as the operator passes over an area of soil the entire width of soil is not penetrated by the tine units. Further, a width of soil equal to the gap between the pair of gang assemblies is not penetrated. This gap requires the operator of the aerator to pass over the same area of soil at least twice in order to penetrate the unaerated portion of soil with the tines.

There is a need for an improved aerator. Certain embodiments of the present invention address these and other needs.

SUMMARY OF THE INVENTION

One aspect of some embodiments of the present invention provides an apparatus for working soil. The apparatus includes a plurality of tine units mounted in series for rotation about a rotational axis. Each of the tine units has a plurality of tines and a first surface with a first set of indexing receivers and a second surface with a second set of indexing receivers. The apparatus includes at least one indexing spacer which separates one tine unit from an adjacent tine unit. The indexing spacer has lugs for assembling with selected ones of the first set of indexing receivers or the second set of indexing receivers of the hub.

Another aspect of some embodiments of the present invention provides an apparatus for working soil. The apparatus includes a frame and a plurality of tine units. Each tine unit has a hub with a plurality of tines extending from the hub. A plurality of indexing spacers is provided, at least one of the

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spacers being used to separate each tine unit from the next adjacent tine unit in the series. Each of the indexing spacers has a first face adapted to repeatedly assemble with and repeatedly dis-assemble from one of the plurality of tine units.

Yet another aspect of some embodiments of the present invention includes an apparatus for working soil including a first gang assembly and a second gang assembly suspended from a frame. The first gang assembly is offset a distance in a direction of travel from the second gang assembly. The first gang assembly and the second gang assembly extend toward a centerline of the frame in the direction of travel. A portion of the first gang assembly intercepts a vertical plane containing the centerline.

Another aspect of some embodiments of the present invention provides a method of indexing tools in an assembly. The method includes providing a shaft, a plurality of tine units, and a plurality of indexing spacers, sliding one of the plurality of tine units onto the shaft for rotation about a rotational axis of the shaft, and sliding one of the indexing spacers onto the shaft for rotation about the rotational axis of the shaft. The method also includes that the indexing spacer orients the tine unit to form an assembly.

Another aspect of some embodiments of the present invention provides an agricultural implement which includes a gang of tine units mounted in series for rotation about an axis, each unit having a hub and tines extending outward relative to said axis and inter-engaging means on said tine units to establish a predetermined angular orientation between adjacent tine units.

Another aspect of some embodiments of the present invention provides a method of indexing tools in an agricultural machine including a plurality of tine units, wherein adjacent tine units include interlocking features designed and adapted to interlock with the interlocking features of an adjacent tine unit in order to maintain said tine units in a predetermined angular orientations as an assembly.

These and other aspects of the present invention will be apparent from the drawings, claims, and text to follow.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top view of an aerator according to one embodiment of the present invention.

FIG. 2 is a perspective view of a gang assembly incorporating an embodiment of the present invention for the FIG. 1 aerator.

FIG. 3 is an enlarged perspective view of a tine unit for the FIG. 2 gang assembly.

FIG. 4 is an enlarged perspective view of an indexing spacer of the FIG. 2 gang assembly.

FIG. 5a is an end view of a right hand tine unit according to one illustrated embodiment of the present invention.

FIG. 5b is an opposite end view of a right hand tine unit of FIG. 5a.

FIG. 6 is a side view of the right hand tine unit of FIG. 5a.

FIG. 7a is an end view of a left hand tine unit according to one illustrated embodiment of the present invention.

FIG. 7b is an opposite end view of a left hand tine unit of FIG. 7a.

FIG. 8 is a side view of the left hand tine unit of FIG. 7a.

FIG. 9 is a perspective view of an indexing spacer according to one illustrated embodiment of the present invention.

FIG. 10 is an end view of the indexing spacer of FIG. 9 taken along line 10-10 in FIG. 9 and viewed in the direction of the arrows.



FIG. 11 is an end view of the indexing spacer of FIG. 9 taken along line 11-11.

FIG. 12 is a side view of the indexing spacer of FIG. 9 taken along line 12-12.

FIG. 13 is a perspective view of an indexing spacer according to another embodiment of the present invention.

FIG. 14 is an end view of the indexing spacer of FIG. 13 taken along line 14-14.

FIG. 15 is an end view of the indexing spacer of FIG. 13 taken along line 15-15.

FIG. 16 is a side view of the indexing spacer of FIG. 13 taken along line 16-16.

FIG. 17 is a perspective view of an indexing spacer according to yet another embodiment of the present invention.

FIG. 18 is an end view of the indexing spacer of FIG. 17 taken along line 18-18.

FIG. 19 is an end view of the indexing spacer of FIG. 17 taken along line 19-19.

FIG. 20 is a side view of the indexing spacer of FIG. 17 taken along line 20-20.

FIG. 21 is a perspective view of an indexing spacer according to another embodiment of the present invention.

FIG. 22 is an end view of the indexing spacer of FIG. 21 taken along line 22-22.

FIG. 23 is an end view of the indexing spacer of FIG. 21 taken along line 23-23.

FIG. 24 is a side view of the indexing spacer of FIG. 21 taken along line 24-24.

FIG. 25 is a perspective view of an indexing spacer according to yet another pattern of spacing lugs.

FIG. 26 is an end view of the indexing spacer of FIG. 25 taken along line 26-26.

FIG. 27 is an end view of the indexing spacer of FIG. 25 taken along line 27-27.

FIG. 28 is a side view of the indexing spacer of FIG. 25 taken along line 28-28.

FIG. 29 is a perspective view of an indexing spacer according to another pattern of spacing lugs.

FIG. 30 is an end view of the indexing spacer of FIG. 29 taken along line 30-30.

FIG. 31 is an end view of the indexing spacer of FIG. 29 taken along line 31-31.

FIG. 32 is a side view of the indexing spacer of FIG. 29 taken along line 32-32.

FIG. 33 is a partial exploded perspective view of a left gang assembly according to one embodiment of the present invention.

FIG. 34 is a perspective view of a mounted gang assembly incorporating an embodiment of the present invention for the FIG. 1 aerator.

#### DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiment illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

FIG. 1 shows an aerator 40 for aerating soil according to one embodiment of the present invention. Typically, the aerator 40 is attached to a tractor (not shown in FIG. 1) to pull the

aerator 40. As discussed below, right refers to the right side of the aerator 40 in the direction of travel and left refers to the left side of the aerator 40 in the direction of travel. The direction of travel is shown in FIG. 1 as an arrow. Aerator 40 comprises a frame 41, a right arm 42 connected to the frame 41, and a left arm 44 connected to the frame 41. The frame 41 includes a right side 46 and a left side 48. Both the right arm 42 and the left arm 44 extend in a forwardly inclined direction converging toward a centerline, C, of the frame 41 in the direction of travel. The right arm 42 extends toward the right side 46 of the frame 41. The right arm 42 and the centerline, C, form an angle, R. The angle, R, is typically in the range of 70° to 90°. The angle, R, can be different in other embodiments. The left arm 44 extends toward the left side 48 of the frame 41. The left arm 44 and the centerline, C, form an angle, L. The angle, L, is typically in the range of 70° to 90°. Aerator 40 further comprises a right gang assembly 50 mounted to the right arm 42 and a left gang assembly 52 mounted to the left arm 44. In one embodiment of the present invention, aerator 40 includes a wheel assembly 54 attached to the rear of the aerator 40. In this embodiment, the wheel assembly 54 includes wheels 56 rotatably mounted to a wheel frame 58.

One embodiment of either the right gang assembly 50 or the left gang assembly 52 is shown in FIG. 2. The right gang assembly 50 is similar to the left gang assembly 52. A typical gang assembly 52 comprises a plurality of tine units 60 and a plurality of indexing spacers 62. For example in FIG. 2, the left gang assembly 52 comprises six tine units 60 and five indexing spacers 62. As another example in FIG. 1, the right gang assembly 50 has nine tine units and the left gang assembly 52 has nine tine units. In some embodiments, each of the tine units 60 is separated from another tine unit by one of the indexing spacers 62. Further, each of the indexing spacers 62 couples with two of the tine units 60 as described below. In some embodiments of the present invention at least one of the tine units 60 intercepts a vertical plane containing the centerline, C, of the frame 41 as shown in FIG. 1, in order to aerate the soil below the centerline.

In the illustrated embodiment, the right gang assembly 50 rotates or turns the same number of degrees between each soil penetration by a tine throughout the full revolution of the right gang assembly 50. Similarly to the right gang assembly 50, the left gang assembly 52 also rotates or turns the same number of degrees between each soil penetration by a tine throughout the full revolution of the left gang assembly 52. Therefore, in some embodiments lighter ballast or no ballast is required to add to the frame 41 to aid the soil penetration of the tines. Beneficially, lighter ballast is easier for the operator to lift or place over the frame 41 and lighter ballast can require a smaller tractor to pull it. In addition, the action of any given tine in the right gang assembly 50 is isolated from the action of the preceding and following tines in the rotation of the right gang assembly 50. Similarly, the action of any given tine in the left gang assembly 52 is isolated from the action of the preceding and following tines in the rotation of the left gang assembly 52. Therefore, the soil is not pinched between the face of one tine and the back-side of the preceding tine as the right gang assembly 50 is rotated or the left gang assembly 52 is rotated.

As shown in FIG. 3, the tine unit 60 includes a plurality of tines 64 integrally formed with a hub 66. The tine unit 60 can be cast from various metals, such as ductile iron or steel, to name a few. Each of the tines 64 includes a tine tip 68 for working the soil as the aerator 40 moves. The tines 64 are triangular in shape, however other shapes may be used as desired. The tines 64 are also preferably the same size in the illustrated embodiment. Each of the tines 64 penetrates into



the soil a similar depth as the gang assembly rotates. The hub 66 is preferably circular in shape. In this embodiment, the hub 66 has a diameter of 5.0". The hub diameter and shape can be different in other embodiments. The hub 66 defines a bore 70 in the center of the hub 66. In the illustrated embodiment, the diameter of the bore 70 is 1.5". In other embodiments, the bore diameter can be different. The hub 66 has a first face 72 and a second face 74 facing in opposite directions. As shown, the width from face to face is 5.7", but in other embodiments the width can be different. First face 72 defines a first interlocking feature, such as indexing receivers or grooves 76, of a first set to enable repeatedly assembling with and dis-assembling from a plurality of indexing spacers 62 having a second set of interlocking features as described below. In this embodiment, the indexing grooves 76 of the first set consist of two indexing grooves, but can be any shape that is interlockable with the second set of interlocking features, including first and second interlocking features that are complementary in shape. Beneficially the first face 72 assembles with and dis-assembles from the indexing spacers 62 which allows a user to quickly change the tine unit 60 for another tine unit, for example, for maintenance of the right gang assembly 50 or the left gang assembly 52. The indexing grooves 76 of the first set are rectangular in shape, however other shapes such as circular, trapezoidal, or square may be used as desired. The indexing grooves 76 are circumferentially indexed through an angle, A, relative to the bore axis, X. In this illustrated embodiment, the angle, A, is 120°. The angle, A, can be different in other embodiments. Second face 74 defines indexing grooves or receivers 78 of a second set to enable repeatedly assembling with and dis-assembling from indexing spacers 62 of another of the plurality as described below. In this embodiment, the indexing grooves 78 of the second set consist of three indexing grooves. In other embodiments, the indexing grooves 78 of the second set can be any number of indexing grooves. The indexing grooves 78 of the second set are rectangular in shape, however other shapes such as circular, trapezoidal, or square may be used as desired. The indexing grooves 78 are circumferentially indexed through an angle, B, relative to the bore axis, X. The angle, B, is 90°. The angle, B, can be different in alternate embodiments.

According to the illustrated embodiment in FIGS. 5a, 5b, and 6, a right hand tine unit 60a is shown. Right hand tine unit 60a is similar to tine unit 60. The right hand tine unit 60a includes a plurality of tines 64a integrally formed with a hub 66a. Each of the plurality of tines 64a includes a cutting edge 65a for engaging the soil. The hub 66a has a first face 72a and a second face 74a facing in opposite directions. First face 72a (FIG. 5b) defines indexing grooves 76a of a first set that are similar to the indexing grooves 76 of the first set of tine unit 60. The indexing grooves 76a are circumferentially indexed through an angle, AR, relative to the bore axis, XR. In this embodiment, the angle, AR, is 120°, however the angle, AR, can be different in alternate embodiments. Second face 74a (FIG. 5a) defines indexing grooves 78a of a second set similar to the indexing grooves 78 of the second set of tine unit 60. The indexing grooves 78a are circumferentially indexed through an angle, BR, relative to the bore axis, XR. In this embodiment, the angle, BR, is 90°, however the angle, BR, can be different in other embodiments.

In an embodiment illustrated in FIGS. 7a, 7b, and 8, a left hand tine unit 60b is shown. Left hand tine unit 60b is similar to tine unit 60. The left hand tine unit 60b includes a plurality of tines 64b integrally formed with a hub 66b. Each of the plurality of tines 64b includes a cutting edge 65b for engaging the soil. The hub 66b has a first face 72b and a second face 74b facing in opposite directions. First face 72b defines indexing

grooves 76b of a first set similar to the indexing grooves 76 of the first set of tine unit 60. The indexing grooves 76b are circumferentially indexed through an angle, AL, relative to the bore axis, XL. In this embodiment, the angle, AL, is 160°, however the angle, AL, can be different in alternate embodiments. Second face 74b defines indexing grooves 78b of a second set similar to the indexing grooves 78 of the second set of tine unit 60. The indexing grooves 78b are circumferentially indexed through an angle, BL, relative to the bore axis, XL. In this embodiment, the angle, BL, is 90°, however the angle, BL, can be different in alternate embodiments.

The right hand tine unit 60a and the left hand tine unit 60b can not be used intermixedly in the right gang assembly 50 and the left gang assembly 52. The indexing grooves of the right hand tine unit 60a and the indexing grooves of the left hand tine unit 60b enable securing the various lugs of the indexing spacers as the gang assemblies are assembled as discussed below. The indexing grooves 76a are circumferentially indexed through an angle different than indexing grooves 76b and the indexing grooves 78a are circumferentially indexed through an angle different than indexing grooves 78b. Therefore, the right hand tine units 60a and the left hand tine units 60b can not be intermixed in the right gang assembly 50 and the left gang assembly 52. Further, the operator can detect the different angles between the indexing grooves of the right hand tine units 60a and angles between the indexing grooves of the left hand tine units 60b to place a tine unit on the appropriate gang assembly.

The right hand tine unit 60a and the left hand tine unit 60b also differ in which edge of the tine is the cutting edge that contacts and cuts into the soil first. The cutting edge 65a of the right hand tine unit 60a is closest to the right side 46 of the frame 41 when the right hand tine unit 60a is assembled in the right gang assembly 50. The cutting edge 65b of the left hand tine unit 60b is closest to the left side 48 of the frame 41 when the left hand tine unit 60b is assembled in the left gang assembly 52. The placement of the cutting edge 65a results in an inward movement of the soil as the soil is cut by the cutting edge 65a. Similarly, the placement of the cutting edge 65b results in an inward movement of the soil as the soil is cut by the cutting edge 65b.

As illustrated in FIG. 4, the indexing spacer 62 includes a first face 80 and a second face 82 facing in opposite directions. In this embodiment, the width from face to face is 2.67", however in alternate embodiments the width can be different. The indexing spacer 62 is circular in shape and defines a passageway 84. The indexing spacer 62 has a diameter of 5.0" in this embodiment, but in other embodiments the diameter may be different. As shown, the diameter of the indexing spacer 62 is the same as the diameter of the hub 66. The passageway 84 is also circular in shape with a diameter of 3.5". It should be appreciated that in other embodiments, the diameter of passageway 84 can be different. First face 80 includes lugs 86 of a first set to enable repeatedly assembling with and dis-assembling from one of either the indexing grooves 76 of the first set or the indexing grooves 78 of the second set of a tine unit. The lugs 86 of the first set are rectangular in shape, however other shapes such as circular, trapezoidal, or square may be used as desired. As illustrated, the lugs 86 of the first set are similar in shape and size as the indexing grooves 76 of the first set in the tine hub face 72 (FIG. 3). Further, each of the lugs 86 is circumferentially indexed through an angle, D, relative to a passageway axis, Y, as shown in FIG. 4. The lugs 86 of the first set are configured to mate or fit with the indexing grooves 76 of the first set in the tine hub face 72. It should be appreciated that the lugs 86 can be exchanged with the indexing grooves 76 such that the first



face **72** of the tine unit can include lugs **86** and the first face **80** of the indexing spacer can include the indexing grooves **76** or each face can include a mix of lugs and indexing grooves. Therefore, wherever lug is mentioned the discussion also applies to indexing groove and wherever indexing groove is mentioned the discussion also applies to lugs. It is understood that the lugs and indexing grooves are interfitting pieces or features of an indexing system. Further, it is understood that reversal of features of the lugs and indexing grooves is intended. Second face **82** includes lugs **88** of a second set to enable repeatedly assembling with and dis-assembling from another of either the indexing grooves **76** of the first set or the indexing grooves **78** of the second set. The lugs **88** of the second set are rectangular in shape, however other shapes such as circular, trapezoidal, or square may be used as desired. In this embodiment, the lugs **88** of the second set are similar in shape and size as the indexing grooves **78** of the second set (FIG. **3**). Further, each of the lugs **88** is circumferentially indexed through an angle, E (not shown in FIG. **4**), relative to the passageway axis Y. In other embodiments, the lugs **86** of the first set can be similar in shape and size as the indexing grooves **78** of the second set and the lugs **88** of the second set can be similar in shape and size as the indexing grooves **76** of the first set. The lugs **88** of the second set are configured to mate or fit with the indexing grooves **78** of the second set.

Although specific types of indexing grooves and indexing spacers have been shown and described, the present invention contemplates other shapes, sizes, and methods for providing a predetermined angular orientation between adjacent tine units. As one example, the present invention contemplates switching the arrangement of lugs on spacers and receivers on tine units, such that there are lugs on the tine units and receivers on the spacers. Further, some embodiments do not include spacers, such that interlocking indexing features are present on the hub of the tine unit, and one hub interlocks directly with another hub. As another example, the present invention contemplates that the hub has tines that attach or detach from the hub. Further, it is contemplated some embodiments have interlocking indexing features on the hub such that the indexing features of a first hub can lock with either indexing features of a second hub or with a spacer.

In the embodiment illustrated in FIGS. **9**, **10**, **11**, and **12**, an indexing spacer **162** is shown. The indexing spacer **162** is similar to the indexing spacer **62**. The indexing spacer **162** includes a first face **180** and a second face **182** facing in opposite directions. In this embodiment, the width from face to face is 2.67", however in alternate embodiments the width can be different. The indexing spacer **162** is circular in shape and defines a passageway **184**. The indexing spacer **162** has a diameter of 5.0" in this embodiment, but in other embodiments the diameter may be different. As shown, the diameter of the indexing spacer **162** is the same as the diameter of the hub **166**. The passageway **184** is also circular in shape with a diameter of 3.5". It should be appreciated that in other embodiments, the diameter of passageway **184** can be different. First face **180** includes lugs **186** of a first set to enable repeatedly assembling with and dis-assembling from one of either the indexing grooves **76** of the first set or the indexing grooves **78** of the second set. The lugs **186** of the first set are rectangular in shape; however, other shapes such as circular, trapezoidal, or square may be used as desired. Further, the lugs **186** are circularly indexed through an angle, D1, relative to a passageway axis, Y1. As illustrated in FIG. **10**, the lugs **186** of the first set include a pair of lugs circularly indexed through the angle, D1, of 121°. In the illustrated embodiment, the first of the lugs **186** is circularly indexed through an angle

F1 measured from a vertical plane, Z. The angle F1 is 2.5° in this embodiment and the angle, F1, can vary in other embodiments. In other embodiments, the number of lugs **186** and the angle, D1, can vary as desired. As shown in FIG. **11**, second face **182** includes lugs **188** of the second set to enable repeatedly assembling with and dis-assembling from another of either the indexing grooves **76** of the first set or the indexing grooves **78** of the second set. In this embodiment, the lugs **188** of the second set consist of three lugs **188**; however, in other embodiments the number of lugs **188** can be different. The lugs **188** of the second set are rectangular in shape, however other shapes such as circular, trapezoidal, or square may be used as desired. In this embodiment, the lugs **188** of the second set are similar in shape and size as the indexing grooves **78** of the second set. Further, the lugs **188** are circularly indexed through an angle, E1, relative to a passageway axis, Y1. As illustrated in FIG. **11**, the angle, E1, is 90°.

In the embodiment illustrated in FIGS. **13**, **14**, **15**, and **16**, an indexing spacer **262** is shown. The indexing spacer **262** is similar to the indexing spacer **62**. The indexing spacer **262** includes a first face **280** and a second face **282** facing in opposite directions. The indexing spacer **262** defines a passageway **284**. First face **280** includes lugs **286** of the first set to enable repeatedly assembling with and dis-assembling from one of either the indexing grooves **76** of the first set or the indexing grooves **78** of the second set. The lugs **286** of the first set are rectangular in shape; however, other shapes such as circular, trapezoidal, or square may be used as desired. Further, the lugs **286** are circularly indexed through an angle, D2, relative to a passageway axis, Y2. As illustrated in FIG. **14**, the lugs **286** of the first set include a pair of lugs circularly indexed through the angle, D2, of 160°. In the illustrated embodiment, the first of the lugs **286** is circularly indexed through an angle, F2, measured from a vertical plane, Z. The angle, F2, is 50° in this embodiment. As shown in FIG. **15**, second face **282** includes lugs **288** of the second set to enable repeatedly assembling with and dis-assembling from another of either the indexing grooves **76** of the first set or the indexing grooves **78** of the second set. In this embodiment, the lugs **288** of the second set consist of three lugs **288**; however, in other embodiments the number of lugs **288** can be different. The lugs **288** of the second set are rectangular in shape, however other shapes such as circular, trapezoidal, or square may be used as desired. In this embodiment, each of the lugs **288** is circularly indexed through an angle, E2, relative to a passageway axis, Y2. As illustrated in FIG. **15**, the angle, E2, is 120°.

In the embodiment illustrated in FIGS. **17**, **18**, **19**, and **20**, an indexing spacer **362** is shown. The indexing spacer **362** is similar to the indexing spacer **62**. The indexing spacer **362** includes a first face **380** and a second face **382** facing in opposite directions. The indexing spacer **362** defines a passageway **384**. First face **380** includes lugs **386** of the first set to enable repeatedly assembling with and dis-assembling from one of either the indexing grooves **76** of the first set or the indexing grooves **78** of the second set. The lugs **386** are circularly indexed through an angle, D3, relative to a passageway axis, Y3. As illustrated in FIG. **18**, the lugs **386** of the first set include a pair of lugs circularly indexed through the angle, D3, of 120°. In the illustrated embodiment, the first of the lugs **386** is circularly indexed through an angle, F3, measured from a vertical plane, Z. The angle, F3, is 30° in this embodiment. As shown in FIG. **19**, second face **382** includes lugs **388** of the second set to enable repeatedly assembling with and dis-assembling from another of either the indexing grooves **76** of the first set or the indexing grooves **78** of the second set. In this embodiment, the lugs **388** of the second set consist of



three lugs **388**; however, in other embodiments the number of lugs **388** can be different. In this embodiment, each of the lugs **388** is circularly indexed through an angle, **E3**, relative to a passageway axis, **Y3**. As illustrated in FIG. **19**, the angle, **E3**, is  $90^\circ$ .

In the embodiment illustrated in FIGS. **21**, **22**, **23**, and **24**, an indexing spacer **462** is shown. The indexing spacer **462** is similar to the indexing spacer **62**. The indexing spacer **462** includes a first face **480** and a second face **482** facing in opposite directions. The indexing spacer **462** also defines a passageway **484**. First face **480** includes lugs **486** of the first set to enable repeatedly assembling with and dis-assembling from one of either the indexing grooves **76** of the first set or the indexing grooves **78** of the second set. The lugs **486** are circularly indexed through an angle, **D4**, relative to a passageway axis, **Y4**. As illustrated in FIG. **22**, the lugs **486** of the first set include a pair of lugs circularly indexed through the angle, **D4**, of  $160^\circ$ . In the illustrated embodiment, the first set of lugs **486** is circularly indexed through an angle, **F4**, measured from a vertical plane, **Z**. The angle, **F4**, is  $40^\circ$  in this embodiment. In alternate embodiments, the number of lugs **486** and the angle, **D4**, can vary as desired. As shown in FIG. **23**, second face **482** includes lugs **488** of the second set to enable repeatedly assembling with and dis-assembling from another of either the indexing grooves **76** of the first set or the indexing grooves **78** of the second set. In this embodiment, the lugs **488** of the second set consist of three lugs **488**. In alternate embodiments, any number of lugs **488** can be used as desired. In this embodiment, each of the lugs **488** is circularly indexed through an angle, **E4**, relative to a passageway axis, **Y4**. As illustrated in FIG. **23**, the angle, **E4**, is  $120^\circ$ ; however, in alternate embodiments the angle, **E4**, can vary as desired.

In the embodiment illustrated in FIGS. **25**, **26**, **27**, and **28**, an indexing spacer **562** is shown. The indexing spacer **562** is similar to the indexing spacer **62**. The indexing spacer **562** includes a first face **580** and a second face **582** facing in opposite directions. The indexing spacer **562** also defines a passageway **584**. First face **580** includes lugs **586** of the first set to enable repeatedly assembling with and dis-assembling from one of either the indexing grooves **76** of the first set or the indexing grooves **78** of the second set. The lugs **586** are circularly indexed through an angle, **D5**, relative to a passageway axis, **Y5**. As illustrated in FIG. **26**, the lugs **586** of the first set include a pair of lugs circularly indexed through the angle, **D5**, of  $120^\circ$ . In the illustrated embodiment, the first set of lugs **586** is circularly indexed through an angle, **F5**, measured from a vertical plane, **Z**. The angle, **F5**, is  $20^\circ$  in this embodiment. In alternate embodiments, the number of lugs **586** and the angle, **D5**, can vary as desired. As shown in FIG. **27**, second face **582** includes lugs **588** of the second set to enable repeatedly assembling with and dis-assembling from another of either the indexing grooves **76** of the first set or the indexing grooves **78** of the second set. In this embodiment, the lugs **588** of the second set consist of three lugs **588**. In alternate embodiments, any number of lugs **588** can be used as desired. In this embodiment, each of the lugs **588** is circularly indexed through an angle, **E5**, relative to a passageway axis, **Y5**. As illustrated in FIG. **27**, the angle, **E5**, is  $90^\circ$ ; however, in alternate embodiments the angle, **E5**, can vary as desired.

Illustrated in FIGS. **29**, **30**, **31**, and **32**, an indexing spacer **662** is shown. The indexing spacer **662** is similar to the indexing spacer **62**. The indexing spacer **662** includes a first face **680** and a second face **682** facing in opposite directions. The indexing spacer **662** also defines a passageway **684**. First face **680** includes lugs **686** of the first set to enable repeatedly assembling with and dis-assembling from one of either the indexing grooves **76** of the first set or the indexing grooves **78**

of the second set. The lugs **686** are circularly indexed through an angle, **D6**, relative to a passageway axis, **Y6**. As illustrated in FIG. **30**, the lugs **686** of the first set include a pair of lugs circularly indexed through the angle, **D6**, of  $160^\circ$ . In the illustrated embodiment, the first set of lugs **686** is circularly indexed through an angle, **F6**, measured from a vertical plane, **Z**. The angle, **F6**, is  $16.5^\circ$  in this embodiment. In alternate embodiments, the number of lugs **686** and the angle, **D6**, can vary as desired. As shown in FIG. **31**, second face **682** includes lugs **688** of the second set to enable repeatedly assembling with and dis-assembling from another of either the indexing grooves **76** of the first set or the indexing grooves **78** of the second set. In this embodiment, the lugs **688** of the second set consist of three lugs **688**. In alternate embodiments, any number of lugs **688** can be used as desired. In this embodiment, each of the lugs **688** is circularly indexed through an angle, **E6**, relative to a passageway axis, **Y6**. As illustrated in FIG. **31**, the angle, **E6**, is  $120^\circ$ ; however, in alternate embodiments the angle, **E6**, can vary as desired.

As shown in FIG. **33**, the left gang assembly **52** will be described in more detail. In this example, the left gang assembly includes a shaft or draw bolt **92** with a first end **94** and an opposite second end **96**. In this example, the length is 5.5 feet; however, in alternate embodiments the length can be different. The first end **94** is closest to the right side **46** and the second end **96** is closest the left side **48** when the left gang assembly **52** is mounted to the left arm **44**. The shaft **92** holds nine left hand tine units **60b**, two indexing spacers **662**, and six indexing spacers **462**. In this example, the left gang assembly **52** is assembled from the first end **94** towards the second end **96**. In other embodiments, the left gang assembly **52** can be assembled from the second end **96** towards the first end **94**. The first left hand tine unit **60b** is slid onto the shaft **92** to the first end **94** such that the second face **74b** is positioned to receive the indexing spacer **462** and the first face **72b** is nearest the first end **94** of the shaft **92**. Next, one of the indexing spacers **462** is slid in the direction of the arrow in FIG. **33** onto the shaft **92** such that the lugs **488** assemble with the indexing grooves **78b** of the first left hand tine unit **60b**. A second left hand tine unit **60b** is slid in the direction of the arrow in FIG. **33** onto the shaft **92** such that the indexing grooves **76b** assemble with the lugs **486**. Next, another one of the indexing spacers **462** is slid in the direction of the arrow in FIG. **33** onto the shaft **92** such that the lugs **488** assemble with the indexing grooves **78b** of the second left hand tine unit **60b**. A third left hand tine unit **60b** is slid onto the shaft **92** such that the indexing grooves **76b** assemble with the lugs **486**. Next, one of the indexing spacers **662** is slid onto the shaft **92** such that the lugs **688** assemble with the indexing grooves **78b** of the third left hand tine unit **60b**. A fourth left hand tine unit **60b** is slid onto the shaft **92** such that the indexing grooves **76b** assemble with the lugs **686**. Next, an indexing spacer **462** is slid onto the shaft **92** such that the lugs **488** assemble with the indexing grooves **78b** of the fourth left hand tine unit **60b**. A fifth left hand tine unit **60b** is slid onto the shaft **92** such that the indexing grooves **76b** assemble with the lugs **486**. Next, another indexing spacer **462** is slid onto the shaft **92** such that the lugs **488** assemble with the indexing grooves **78b** of the fifth left hand tine unit **60b**. A sixth left hand tine unit **60b** is slid onto the shaft **92** such that the indexing grooves **76b** assemble with the lugs **686**. Next, another of the indexing spacers **662** is slid onto the shaft **92** such that the lugs **688** assemble with the indexing grooves **78b** of the sixth left hand tine unit **60b**. A seventh left hand tine unit **60b** is slid onto the shaft **92** such that the indexing grooves **76b** assemble with the lugs **686**. Another indexing spacer **462** is slid onto the shaft **92** such that the lugs **488** assemble with the indexing grooves



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78*b* of the seventh left hand tine unit 60*b*. An eighth left hand tine unit 60*b* is slid onto the shaft 92 such that the indexing grooves 76*b* assemble with the lugs 486. Yet another indexing spacer 462 is slid onto the shaft 92 such that the lugs 488 assemble with the indexing grooves 78*b* of the eighth left hand tine unit 60*b*. A ninth left hand tine unit 60*b* is slid onto the shaft 92 such that the indexing grooves 76*b* assemble with the lugs 486 and the second face 74*b* is nearest the second end 96.

In the example in FIG. 33, the first end 94 and the second end 96 are each attached to the left arm 44 in the same manner. The left gang assembly 52 includes an end spacer 98 as shown in FIG. 33. A first end spacer 98 is slid onto the first end 94 of the shaft 92 next to the first face 72*b* of the first left hand tine unit 60*b*. A second end spacer 98 is slid onto the second end 96 of the shaft 92 next to the first face 72*b* of the ninth left hand tine unit 60*b*.

The left gang assembly 52 also includes a Belleville washer 100 as shown in FIG. 33. A first Belleville washer 100 is slid onto the first end 94 of the shaft 92 next to the first end spacer 98. A second Belleville washer 100 is slid onto the second end 96 of the shaft 92 next to the second end spacer 98. As should be appreciated, the Belleville washer 100 is a spring washer.

The left gang assembly 52 further includes a burnout end spacer 102 placed next to first Belleville washer 100 and the second Belleville washer 100. As should be appreciated, the end spacer maintains an adequate clearance between the bearing assembly and other components.

As shown in FIG. 33, the left gang assembly 52 includes a trunion bearing assembly 104 that slides onto the shaft 92. The first trunion bearing assembly 104 is slid onto the first end 94 of the shaft 92 next to the burnout end spacer 102. A second trunion bearing assembly 104 is slid onto the second end 96 of the shaft 92.

The left gang assembly 52 further includes a washer 106 that slides onto the shaft 92. A first washer 106 is slid onto the first end 94 of the shaft 92 next to the first trunion bearing assembly 104. A second washer 106 is slid onto the second end 96 next to the second trunion bearing assembly 104.

As shown in FIG. 33, the left gang assembly 52 includes a castellated nut 108 screwed onto the shaft 92 and locked by a spring pin 110. This secures the left hand tine units 60*b*, the indexing spacers 662, and the indexing spacers 462 in an assembled position.

Each end of the left gang assembly 52 is mounted to left arm 44 by a flex member 114 clamped to left arm 44 as shown at the left-hand side of FIG. 33. The flex member 114 can bend to allow the shaft 92 to move vertically as the aerator 40 moves horizontally. For example, the flex member 114 enables the left gang assembly 52 to traverse rocks while the aerator 40 is pulled by the tractor. The flex member 114 can be made of any material that allows the flex member 114 to bend elastically, such as ductile iron or steel. The flex member 114 is a "C" shape; however, other shapes can be used as desired. The flex member 114 also defines holes 111. A bar 112, a set of bolts 116, a plate 118, and a set of nuts 120 attach the flex member 114 to the left arm 44 as shown in FIG. 33. The bar 112 defines a pair of holes for receiving the bolts 116. The plate 118 also defines holes for receiving the set of bolts 116. The bar 112 is placed next to the flex member 114 as shown in FIG. 33 and two of the bolts 116 are placed through the pair of holes in bar 112. Next, the plate 118 is placed on the left arm 44 as shown in FIG. 33. The set of bolts 116 are inserted through the holes in plate 118, and the set of nuts 120 are screwed onto the set of bolts 116 to clamp the flex member 114 to the left arm 44. Next, the ends of the left gang assembly 52 are attached to the flex members 114 with a pair of trunion

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mounts 122 and a pair of bolts 124. Each of the trunion mounts 122 also defines a hole 126 as shown in FIG. 33. The trunion mounts 122 are attached to the trunion bearing assembly 104. Each of the bolts 126 is inserted through the hole 111 and the hole 126 to mount each end of the left gang assembly 52 to the flex member 114.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiment has been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected.

What is claimed is:

1. An apparatus for working soil, comprising:

a frame having a hitch to be pulled behind a tractor in a direction of travel;

at least two gang assemblies mounted to said frame, wherein one of said at least two gang assemblies is offset a distance in a direction of travel from a second of said at least two gang assemblies, and wherein each gang assembly extends in a forwardly inclined direction converging from an outside of said frame toward a centerline of said frame in the direction of travel;

wherein each gang assembly includes a plurality of tine units slidable onto a shaft to mount said tine units in series for rotation in unison across the width of said shaft, each of said tine units is rotatable about said shaft, each of said tine units having a hub and a plurality of tines extending from said hub;

wherein said hub has a first surface defining a first set of indexing features and a second surface defining a second set of indexing features, said first set of indexing features is different in number than said second set of indexing features; and

a plurality of indexing spacers slidable onto said shaft for mounting thereon, said plurality of indexing spacers is rotatable about said shaft, said plurality of indexing spacers having a third set of indexing features thereon, at least one indexing spacer of said plurality of indexing spacers separating each tine unit from the next tine unit in said series of tine units, and for assembling said tine units and said spacers on said shaft with said third set of indexing features of said indexing spacers interlocked with selected ones of said first set of indexing features or said second set of indexing features.

2. The apparatus of claim 1 wherein said tine units establish and maintain a predetermined angular orientation of said tines.

3. The apparatus of claim 1 wherein each of said indexing spacers includes a first face and a second face, said first face being adapted to interlock with either one of said first set of indexing features or said second set of indexing features, and said second face being adapted to interlock with the other one of said first set of indexing features or said second set of indexing features.

4. The apparatus of claim 1 wherein said at least two gang assemblies are suspended from said frame.

5. The apparatus of claim 4 wherein a portion of a first of said at least two gang assemblies intercepts a vertical plane containing the centerline.

6. The apparatus of claim 4 wherein a portion of the second of said at least two gang assemblies intercepts a vertical plane containing the centerline.

7. The apparatus of claim 4 wherein said forward inclination of said first gang assembly is an angle in a range from about 70° to about 90° to said direction of travel.



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8. The apparatus of claim 4 wherein said forward inclination of said second gang assembly is an angle in a range from about 70° to about 90° to said direction of travel.

9. The apparatus of claim 1 wherein said hub and said plurality of tines extending from said hub are integrally cast to form each of said tine units.

10. An apparatus for working soil comprising:

a frame having a hitch to be pulled behind a tractor in a direction of travel;

at least two gang assemblies mounted to said frame, wherein one of said at least two gang assemblies is offset a distance in a direction of travel from a second of said at least two gang assemblies, and wherein each gang assembly extends in a forwardly inclined direction converging from an outside of said frame toward a centerline of said frame in the direction of travel;

wherein each gang assembly includes a plurality of tine units slidably and rotatably mounted on a shaft for rotation, each tine unit of said plurality of tine units having a hub and a plurality of tines extending from said hub; a plurality of indexing spacers for separating each tine unit of said plurality of tine units from the next adjacent tine unit of said plurality of tine units, each of said indexing spacers having a first face and a second face;

said first face having a first set of indexing features configured to repeatedly assemble with and repeatedly disassemble from one of said plurality of tine units, said first set of indexing features includes a plurality of projections in a first circumferential pattern;

said second face having a second set of indexing features, said second set of indexing features includes a plurality of projections in a second circumferential pattern, said second set of indexing features being different than said first set of indexing features, said second set of indexing features configured to repeatedly assemble with and repeatedly disassemble from another of said plurality of tine units; and

wherein said first set of indexing features and said first face, and said second set of indexing features and said second face are integrally cast to form each of said indexing spacers.

11. The apparatus of claim 10 wherein said first set of indexing features comprises a first plurality of lugs for repeatedly assembling with and repeatedly dis-assembling from one of said plurality of tine units.

12. The apparatus of claim 11 wherein said second set of indexing features comprises a second plurality of lugs for repeatedly assembling with and repeatedly dis-assembling from another of said plurality of tine units.

13. The apparatus of claim 10 wherein said hub and said plurality of tines extending from said hub are integrally cast to form said tine unit.

14. An apparatus for working soil comprising:

a frame having a hitch to be pulled behind a tractor in a direction of travel;

at least two gang assemblies mounted to said frame, wherein one of said at least two gang assemblies is offset a distance in a direction of travel from a second of said at least two gang assemblies, and wherein each gang assembly extends in a forwardly inclined direction converging from an outside of said frame toward a centerline of said frame in the direction of travel;

wherein each gang assembly includes at least a pair of tine units configured to slide onto and rotate about a shaft, said pair of tine units mounted on said shaft for rotation,

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each tine unit of said pair of tine units having a hub and a plurality of tines extending from said hub; and an indexing spacer for separating said pair of tine units, said indexing spacer configured to slide onto and rotate about said shaft, one side of said indexing spacer having a first set of indexing features in interlocking contact with the hub of a first one of said tine units and a second side of said indexing spacer having a second set of indexing features in interlocking contact with the hub of a second one of said tine units, wherein the first set of indexing features is different in number than the second set of indexing features.

15. The apparatus of claim 14 wherein said hub has a first surface defining a first set of indexing receivers and a second surface defining a second set of indexing receivers, wherein the first set of indexing receivers is different than the second set of indexing receivers.

16. The apparatus of claim 14 wherein said indexing spacer maintains said tine units in a predetermined rotational index orientation of said tines.

17. An apparatus for working soil comprising:

a frame having a hitch to be pulled behind a tractor in a direction of travel;

at least two gang assemblies mounted to said frame, wherein one of said at least two gang assemblies is offset a distance in a direction of travel from a second of said at least two gang assemblies, and wherein each gang assembly extends in a forwardly inclined direction converging from an outside of said frame toward a centerline of said frame in the direction of travel;

wherein each gang assembly includes a plurality of tine units configured to slide onto and rotate about a shaft, said plurality of tine units supported by said shaft for rotation about an axis, each said tine unit having a hub and a plurality of tines extending from said hub, a first side of each said hub extending about the axis on one side of the corresponding plurality of tines, a second side of each said hub extending about the axis on the other side of the corresponding plurality of tines; and

wherein each first side has a first indexing feature and each second side has a second indexing feature, said first indexing feature is different in number than said second indexing feature.

18. The apparatus of claim 17 wherein either of said first indexing feature or said second indexing feature defines at least one indexing receiver.

19. The apparatus of claim 17 wherein said plurality of tine units establish and maintain a predetermined angular orientation of said tines.

20. The apparatus of claim 17 further comprising an indexing spacer for separating said first tine unit from said second adjacent tine unit of said pair of tine units.

21. The apparatus of claim 4 wherein each gang assembly has a pair of ends suspended from said frame with a pair of elastically bendable flex members which allows the shaft to move vertically as said frame moves horizontally.

22. The apparatus of claim 21, wherein said flex members are each formed in a C shape.

23. The apparatus of claim 17 wherein each gang assembly has a pair of ends suspended from said frame with a pair of elastically bendable flex members which allows the shaft to move vertically as said frame moves horizontally.

24. The apparatus of claim 23, wherein said flex members are each formed in a C shape.